d. Apr. 1871

RY

T. Forbes

PROTECTION

OF

SHIPS FROM LIGHTNING.

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SHIPS FROM LIGHTNING,

ACCORDING TO PRINCIPLES ESTABLISHED BY

SIR W. S. HARRIS, F. R. S.

AND APPROVED AFTER

EIGHTEEN YEARS' EXPERIENCE IN THE BRITISH NAVY.

COMPILED FROM

"HARRIS ON THUNDER STORMS," AND FROM A PAMPHLET PUBLISHED IN 1847, BY HARRIS, ENTITLED "REMARKABLE INSTANCES OF PROTECTION OF CERTAIN SHIPS OF HER MAJESTY'S NAVY," &c. &c.

BY R. B. FORBES.

BOSTON:
PRINTED BY SLEEPER & ROGERS,
(DAILY JOURNAL OFFICE.)
1848.

PREFACE.

The protection to ships from lightning, although a very *attractive* subject, has not elicited that practical attention which its importance deserves. The cause of humanity, not less than self-interest, demands that all ships should be furnished with properly adjusted conductors, fixed in their places, independently of the officers and crew. My object in this publication will be to bring before the public the most prominent facts to sustain the theory and practice of Harris's conductors, and to this end I shall quote largely from the works above alluded to, not claiming any originality in the matter, but desiring only to serve the cause of humanity and economy, by introducing, if possible, the conductors in question into this country. If I succeed, I shall feel that I have "done the State some service." During some considerable experience at sea, in all climates, I have been so fortunate as never to have witnessed any very destructive effect of lightning, but I have passed many anxious moments when the lightning was flashing around, and I should have felt comparatively easy if I had been properly protected, and had faith in the means. I have always considered the common chain conductors in use in our navy, and occasionally in our merchant service, as little better than nothing; not because they "attract the fluid," but because they are so often out of place when the stroke comes, or rendered useless by it.

A strong prejudice exists in the minds of sailors against conductors, believing that they "attract the electric fluid,"

which is abundantly shown in Harris's works to be imaginary; and I think there is no more reason for dispensing with lightning conductors because they *may* receive a stroke occasionally, which would pass off elsewhere without them, than for dispensing with a good fire in one's house because once in a while accidents occur from them! Conductors are in general use on our houses and barns and public buildings, and it is generally admitted that they are eminently useful when properly applied; why then should the ship—a lone object on the ocean, far from any helping hand, and on an element little less dangerous than fire—be left unprotected? The answer is, simply because we have little faith in the means within our knowledge, or in general use for ships, while we have faith in the same means applied to houses and barns. We know of many ships damaged and destroyed by lightning, and there have been many lost whose fate is only known to an all-seeing Providence. All such might have been saved by properly applied conductors, and I hope that at some future day the underwriters will have so much faith in this fact, that among the first questions asked when applied to for insurance on a ship or cargo, will be, "Has she Harris's conductors?"

I make no pretension to scientific knowledge on the subject of the electric fluid, but I have full faith in the facts stated by Mr. Harris, whom I quote specially on the subject of conductors for ships, recommending all who feel inclined to examine his theories on the natural properties of the electric fluid, to read his work "on the nature of thunderstorms," published in London, by John W. Parker, in which the theory and practice of his conductors is fully treated and illustrated by plates.

Extract from a Letter of Sir W. S. HARRIS, dated April 7, 1848, to R. B. Forbes.

"I have yours of the 10th March, and I beg to assure you that I shall have much pleasure in using my best endeavors to forward your views relative to the application of my conductors.

"The principle and application of the conductors is very simple and easily understood, especially by inspection, but it is not so easy to perfect the application of the conductors without it. We had a great deal of trouble in carrying out the plan, at first, in the Queen's Dock Yards, which is now an easy and common routine in the service. *Every ship in the British Navy is fitted*, and the East India Company has followed the example of our Government in their Indian Navy.

"I quite agree with you, as to the common chains, or other conductors of a temporary form applied as rigging,—they are neither safe nor efficient, as I have fully shown in my pamphlet. My conductors are based upon more general principles than are usually entertained in the consideration of lightning conductors generally. My object is to bring the whole mass of the ship, from truck to keel, into that perfectly conducting or passive state it would assume as regards lightning, supposing the whole were metallic throughout. To effect this, a line of copper sheet, in two layers, is incorporated with the masts, from truck to shoe, forming a series of shut joints, and so applied as to withstand any strain to which the spars may be subjected. Then we have bands of copper applied in a similar way under the beams leading to the iron knees or metallic fastenings passing through the side

of the ship, and also fore-and-aft bands from the fore-mast to the stem, and from the mizen-mast to the stern-post, whilst the conductors at the steps of the masts unite with metallic bolts passing through kelson and keel to the water, and thus the conductors at the mast head become tied as one great connecting link with all the metallic masses in the hull, and with the sea, and it has been proved by eighteen years' experience in the British Navy, that directly as lightning strikes aloft upon the conductor all the dangerous and explosive action vanishes.

"With regard to the expense of the conductors, I have only to observe that it is reducible to the labor of fitting and interest on the outlay; the material supplied is so much *bona fide* property, always convertible into money, at the market price of copper. The conductors have saved to this country from £3,000 to £10,000 annually, in material alone, besides the safety of its fleets. We have saved, within twenty months, full eight ships from whole or partial destruction, as you will see by my pamphlet, and we have, since its publication, accounts of others."

Signed, W. SNOW HARRIS.

INTRODUCTORY OBSERVATIONS, &c.

The Official Journals of the British Navy present, from the earliest period of its history, melancholy and often fatal instances of the destructive action of Lightning. In about 120 cases only, the amount of money sunk on account of masts and other material ruined or destroyed, cannot be set down, on a moderate computation, at less than 100,000*l.* Three hundred seamen either lost their lives or were seriously injured, and the country was frequently deprived of the efficient services of its ships and fleets at critical periods. Between the years of 1810 and 1815, we find records of no less than thirty-five sail of the line, thirteen frigates, and ten sloops, either disabled or greatly damaged. Taking into the account every instance in which ships of the Royal Navy have suffered from lightning since the war in 1793, and every expense contingent on the repairs and refit of the ships, the country did not certainly, on a moderate estimate, expend less than from 7,000*l.* to 10,000*l.* annually, during a period of about twenty-three years' war, and from 2,000*l.* to 5,000*l.* for about the same period of peace, in consequence of damage done to its navy by lightning.

A want of due attention to the means of parrying the force of the electrical discharge, may be considered as the more immediate cause of so much devastation. Our ships have either been unprovided with lightning-conductors altogether, or if furnished with them, they have been of such small capacity, so partially and ill-applied, and so dependent on the prejudices of sailors, for due care and attention to them, that little benefit seems to have been derived from this source of protection.

That the common temporary forms of lightning-conductor, applied as rigging, do not satisfy all the conditions of the problem, or meet the many difficult circumstances in which

the general fabric of a ship, in all its casualities, may become placed, is now pretty generally admitted. In certain cases of electrical discharge, this kind of conductor may be partially destroyed; or otherwise, from its misapplication, or from its constituting an imperfect line of discharge, or from lightning striking low down, or obliquely, upon the mast, it may fail to afford the required protection. The results of the trials resorted to by the Board of Admirality, [1839 to 1842,] are quite conclusive upon this point, even if all former experience had not already determined the fact. The following are two extracts from the log of H. M. S. *Hazard*, lately returned from China, and which, in 1841, was ordered to be furnished with lightning-conductors consisting of small ropes of wire led from the truck to the sea, along the rigging and over the ship's side; their lordships having been informed, that ropes of this kind would prove more economical, and be more safe, than a more capacious and permanent kind of conductor fixed in the masts and hull:—

"Diamond Point, north end of Sumatra, May 1, 1846, A. M. 3.35. In royals and flying jib—up mainsail. 5, set top-gallant sails. 7, ship struck by lightning, splitting masthead vane-staff, and carrying away the conductor. Maintop-sail sheet-bits damaged. Lightning passed down by the starboard maintop-sail chain-sheet and by the wire conductor, tearing copper off the ship's side, and materially injuring the wire, by breaking the strands."

"Cape Po, Sarawak, Borneo, June 12, 1846; at anchor, A. M. 5.30.—Lightning struck the ship, splitting and carrying away maintop-gallant and royal-mast, the whole of maintop-mast, from the hounds to the lower cap, sprung after cross-tree, split and carried away starboard trussel-tree. The electric fluid partly escaped down the conductor by main rigging overboard. A part of the damaged topmast on falling went through the quarter-deck into the gun-room. 8, cleared the wreck, and pointed new maintop-mast," &c.

In referring to the log of H. M. S. *Bittern*, another of the vessels in which these conductors were ordered to be tried, we find a similar result, as shown in the following extract from the log:—

"Angorha River, Jan. 23, 1844, P. M. 10.20.—Struck by lightning, which shivered the main-truck, and splintered the royal-mast."

It further appears, by the medical officer's report, that the discharge fell on the deck, and disabled several of the sailors: eight men were sent to the hospital. A great portion of the discharge, however, is said to have passed off by the conductor, so far contributing to protection. These are not solitary instances; Arago, in his "Notices sur Le Tonnerre," Annuaire for 1838, p. 515, gives a similar case, as occurring in *La Junon*, a French frigate, which had a rope of twisted wires applied as a lightning-conductor in the rigging. In the "Comptes Rendus," for June 1839, we find an account of damage by lightning to l'Hotel des Invalides at Paris, in which case the lightning-conductor of twisted wire ropes was knocked in pieces. In H. M. ships *Impregnable* and *Belleisle*, two line-of-battle ships, these ropes were chafed through by the working of the gear aloft, and were returned as defective to the Devonport dockyard; and these are not the only instances of this, besides others in which they have been found either misapplied or out of place. The Commission for inquiring into the best form of lightning-conductors for ships, appointed in 1839 by the Board of Admirality, under the countenance of the House of Commons, gave in their Report numerous examples of the inapplicability of these temporary expedients to meet the exigencies of a ship in storms of lightning, and to resist the violent mechanical forces to which a ship's rigging is exposed,* and concur fully in the opinion advanced by almost every practical seaman, that if lightning-conductors are applied at all on shipboard, they should be applied under a capacious and permanent form, so as to render them secure, and independent of the crew of the ship for their perfect application and preservation. This has lately become an affair of no inconsiderable moment, since it is now found requisite to apply a conductor to each mast; hence it follows that the officers and seamen have to look after three conductors instead of one, as in former times, all of which is considered a great source of peril and annoyance, especially in gales of wind and in thunder-storms. But then the question arose, how far metallic conductors, of a fixed and capacious kind, can be applied so as to meet all the varying conditions of a ship's masts, and all the casualities in which the vessel itself may become placed—a problem more difficult of solution than would at first be imagined. It, in fact, amounts to this:—to construct and apply lightning-conductors in ships, so as to be always in place, always ready to meet the most

* Shipwreck by Lightning.—Report and Evidence printed by the House of Commons, February, 1840.

unexpected danger; to be permanently fixed and of great capacity, admitting, at the same time, not only of every possible motion of the different parts of the masts one on the other, but also of any portion of the mast being removed, either by accident or design, without in any way interfering with the protecting power; to be quite independent of the officers and crew of the ship, so as not to impose upon them the responsibility of their correct application, or the necessity of watching and handling them, of placing and replacing them in times of difficulty, to their great peril and annoyance; to be quite clear of the standing and running rigging, capable of resisting external violence, and at the same time yield to any flexure the mast can sustain; finally, to be so applied, that a discharge of lightning falling on the ship cannot enter into any circuit in its passage to the sea, of which the conductors do not constitute a part. Such are the principal conditions we have to satisfy in any attempt to effectually secure shipping against the destructive ravages of lightning.

To meet such complicated conditions the author of these remarks proposed, so long since as the year 1820, to give the ship a perfectly continuous conducting power throughout the masts and hull, by incorporating with the masts a line of double copper plates, of great electrical capacity, applied one over the other in alternating close joints, so as to yield with the flexure of the spar, being firmly imbedded in a shallow groove ploughed in the after part of it. These flexible metallic lines to be finally connected with similar conductors, fixed under the beams and in the body of the ship, and connected with all the great metallic masses employed in the construction of the hull, and with the sea; thus bringing the general fabric into that peculiar electrical position it would assume, supposing the whole were metallic throughout. Thus the conductor, all the minor mechanical details being perfected, became an integral portion of the ship and masts, and the vessel consequently made secure against the violent action of lightning at all times and under all circumstances, without the officers and crew of the ship being parties to it in any way whatever.

So bold an application of the general principles of lightning-conductors was not at first received without much distrust and apprehension; almost every one having been led to imagine that metallic bodies had a peculiar affinity for the matter of lightning, and by inviting or drawing it down upon the ship, frequently accelerated the mischief they were meant to obviate; that from the position of the conductors the electrical discharge

would necessarily pass through the body of the hull, whilst the variable positions which the sliding masts were liable to assume would derange the line of conduction, and hence damage might ensue. The author, however, succeeded in proving, by new researches in electricity and by a very extensive induction of facts derived from the analyses of numerous instances in which ships of H. M. Navy had suffered from lightning, that such apprehensions were not tenable; that what we term lightning being nothing more than an explosive form of action of some occult power in nature when forcing its way through resisting matter, we should, in giving it a free passage through little resisting matter, transform this explosive action, termed lightning, into a comparatively quiescent current, and so avoid those violent results arising from disruptive force altogether; that every species of matter was really in itself indifferent to the agency of lightning, which only seized upon bodies generally when they happened to be in a position to assist its progress, the course of the discharge being determined by certain laws of resistance altogether independent of any attractive power supposed to exist in them; that provision being made for the continuity of the conductor from one mast to the other, in whatever position the sliding masts were placed, a line of least resistance to the sea would be always provided; the electrical discharge would hence certainly move in that line, and in no other; and in that, too, without any intermediate explosion.

Full fifteen years' experience of these principles in H. M. Navy have proved them to be sound in science and available in practice; not only has it been found that ships thus fitted have, by the rapid transmission of electrical action, come securely and tranquilly out of most severe lightning storms in various latitudes and climates, but even in cases in which heavy and furious discharges of thunder and lightning have eventually burst on the ship, still not the least ill consequence has ensued.

It must be admitted to be a great practical fact, that whereas in former years the country expended large sums of money in repairing the damage done to its Navy by lightning, and occasionally lost the full services of its ships and fleets, to say nothing of the lives of its seamen,—now, that the complete employment of the general and permanent method of conductors in the Navy has been fully carried out, damage to H. M. ships by the destructive element of lightning is quite unknown.

The following remarkable instances in which capacious conductors, forming a portion of the ship together with the masts, have guarded certain of H. M. ships, and those on board, against heavy shocks of lightning, may be considered as so many grand experiments on the gigantic scale of nature; they are hence of singular importance not only to the department of physical science, to which they relate, but they are also of no small consequence to the public interest and future welfare of the Navy. They are hence not unworthy of a place in the records of science.

REMARKABLE INSTANCES

OF THE PRESERVATION OF SHIPS OF THE ROYAL NAVY IN STORMS OF LIGHTNING.

ACTÆON, 26.

This ship, during the years 1840 and 1841, was repeatedly exposed to lightning storms in tropical and southern latitudes. The following is an interesting and very clear account of the phenomena attendant on a burst of lightning and thunder, which fell on the masts of this vessel, and the protecting effect of the conductor, as given by Lieut. Bonham, then officer of the watch:—

"When off the coast of Central America, in H. M. S. *Actæon*, on the morning of the 23d July, 1841, I, being officer of the middle watch, having heavy squalls of rain, thunder, and lightning, had shortened sail, and was running with square yards, wind to the eastward, sky very dark. Whilst standing on the larboard side of the quarter-deck, between the main-mast and binnacle, and looking towards the main-top, a most tremendous clap of thunder burst over our mast-heads, the lightning appearing at the same time to run down the conductor. There was no interval of time that I perceived, between the flash and the report of the thunder; I saw nothing for several minutes after; the Quarter Master of the watch, Henry Love, also observed it, and said to me afterwards, it was the sharpest lightning he had ever seen, and was surprised that we were neither of us injured by it. I believe the conductor saved the mast, and probably some men's lives.

(Signed) "C. W. Bonham, *late of H. M. S. Actæon.*"

Mr. May, the carpenter of the *Actæon*, states that at the time the cloud burst on the ship,—

"He was standing with his back against the pump winches, near the main-mast, when there came a crash of thunder directly overhead, as if the ship's broadside had been fired. He says it was an awful sound, and attended by a loud whizzing noise; the ship fairly shook under it. He felt the pump gear, against which he was leaning, tremble; the cutlasses, stowed about the main-mast, rattled in the stand; a momentary vivid flash seemed to strike the conductor, the effect of which in discharging the lightning was truly beautiful. The night was awfully dark, with a heavy sea; no damage or inconvenience was experienced; he examined the conductors, as carpenter of the ship, after the squall, and found them quite perfect."

This was not the only instance in which the conductors saved the *Actæon* from damage.

AMERICA, 50.

A tremendous clap of thunder, preceded by vivid lightning, is reported to have fallen directly on the foremast of the *America*, on the evening of the 30th January, 1847, which, as stated in the official report of the ship's qualities, &c., was immediately carried off by the conductors without any damage having occurred. The ship was at anchor at Corunna, and those on deck who witnessed the explosion made an immediate report to the captain. The day had been cloudy and threatening, followed toward the afternoon by heavy rain, with sharp lightning and thunder. The following is the statement made in the ship's official Journal:—

"H. M. ship *America*, at Corunna, Jan. 30, 1847, P. M. 4h. 45m. Fresh breezes N. N. W.; cloudy, with lightning, thunder, and rain. Foremast struck by lightning, which appeared to escape by Harris's conductor on starboard side of the lower deck."

The system of conductors carried out in this ship evidently dispersed a severe shock of lightning with great ease, such as under similar circumstances has shivered the spars, and caused other damage.

ASIA, 84.

The following is the account given by Mr. Sadler, master, R. N., of a stroke of lightning which fell on this fine ship, in the Tagus, in November, 1831, but which was instantly dispersed by the conductor:—

At the close of the day a gale set in from the west, accompanied by clouds, with rain, thunder, and lightning During a heavy squall, and whilst standing under the poop awning, in conversation with Captain Hyde Parker, a sudden flash, with an instantaneous clap of thunder, burst over us. I was convinced that the main-mast had been struck, but being fitted with Mr. Harris's conductors, we experienced no inconvenience. I have always felt satisfied, that had we not been so fitted, our main-mast must have been shattered, and I think Captain Parker was of the same opinion. No official report, however, was ever made upon the *Asia's* being struck by the electrical discharge."

Mr. Sadler, whose services are well known and appreciated in the navy, was formerly the master-attendant at the Chatham Dockyard; and no one acquainted with him would for a moment question the accuracy of his judgment as a careful observer. It further appears, that in consequence of the thunder and lightning, the people were all sent below, the ship being at the time moored in the Tagus.

BEAGLE, 10.

The *Beagle*, during her late voyages in the southern hemisphere, was more than once struck by discharges of lightning. On one occasion, in the Rio de la Plata, the shock appears to have been very severe. Captain Sullivan, then first lieutenant of the *Beagle*, thus describes the phenomena he witnessed:—

"I was first lieutenant of the *Beagle*, and was attending to my duty on deck. The ship was at anchor off Monte Video, in the Rio de la Plata, a part of the world often visited by severe thunder-storms. Having served in H. M. S. *Thetis* a few years before, when her *foremast was entirely destroyed by lightning*, at Rio Janeiro, my attention became particularly directed to approaching electrical storms. On this occasion the storm was unusually severe; the flashes of lightning succeeded each other in rapid succession, and were gradually approaching. I was watching for them aloft, when the ship apparently became wrapped in a blaze of fire, accompanied by a simultaneous crash, which was equal if not greater than the shock I felt in the *Thetis*. One of the clouds by which we were surrounded had evidently burst on the vessel, and as the main-mast, for the instant, appeared to be a mass of fire, I felt certain that the lightning had passed down the conductor

on that mast, The ship was shaken by the shock, and an unusual tremulous motion could be distinctly felt.

"So soon as I had recovered from the surprise of the moment, I ran down below to see if the conductors there had been affected; and just as I entered the gun-room, the purser, Mr. Rowlett, ran out of his cabin (along the beam of which a main branch of the conductor passed,) and said he felt certain that the lightning had come down the conductor, for at the instant of the shock he heard a vibrating sound, like rushing water along the beam. Not the slightest ill consequence was experienced; and I cannot refrain from expressing my conviction, that but for the conductor the result must have been serious."

This occurred in August, 1832. Captain Fitzroy, who commanded the *Beagle*, on his return to England, made the following report to the Lords Commissioners of the Admirality:—

"Previously to sailing from England in 1831, the *Beagle* was fitted with the permanent lightning conductors invented by Mr. Snow Harris. During the five years occupied in her voyage, we were frequently exposed to lightning, but never received the slightest damage, although supposed to have been struck on *at least* two occasions.

"At each of these times, at the instant of a vivid flash of lightning accompanied by a crashing peal of thunder, a hissing sound was distinctly heard on the masts, and a strange though slightly tremulous motion in the ship indicated that something unusual had happened.

"No objection which appeared to me valid was ever raised against them; and were I allowed to choose between masts so fitted and the contrary, I should decide in favour of those having Harris's conductors: even in the small spars the plates of copper held their places firmly, and increased rather than diminished their strength."

In February, 1842, the *Beagle*, whilst under the command of Captain Stokes, was again struck by lightning whilst on survey on the coast of South Australia. Captain Stokes, who has published an interesting account of these voyages, reports "that the electric fluid passed down the mizen-mast without injury to the ship or spars. An officer was within a foot of the mast at the time, but experienced no inconvenience beyond a slight alarm at the instant, when a vibrating rattle occurred." Captain Stokes further states that the spars were still the same, having been fitted with the conductors in 1831,

a period of full eleven years—a clear proof, says he, "that they do not weaken the masts."

DRUID, 44.

The *Druid* is stated by Captain Norcott, R. N., to have been in "awful lightning, at Rio Janeiro," which was conducted, without damage, "down the fore and main-masts."

Vide Shipwreck by Lightning, Report and Evidence, &c., printed by the House of Commons, February, 1840, p. 90.

DRYAD, 44.

Captain Turner, R. N., late of the *Dryad*, states in evidence, "That in a tornado, on the coast of Africa, both the foremast and mizen-mast were struck by lightning; the ship appeared enveloped in flames; the thunder was very loud, and instantly succeeded the lightning." He further states "That whilst standing on the quarter-deck during one of the flashes, I distinctly saw the lightning run down the conductor on the foremast, and the officer on the forecastle came and told me he heard a hissing noise, resembling the boiling of water; all the men there heard it also. A short time afterwards, several of the officers standing abaft saw it, at the time of another flash, go down the mizen-mast, and heard the same hissing noise."

In allusion to the conductors, he adds, "Carrying sail has no effect upon them; we carry a heavy press of sail sometimes."

Vide Shipwreck by Lightning, Report and Evidence, &c., printed by the House of Commons, February, 1840, p. 29 and p. 48.

DAPHNE, 18.

A flash of lightning fell on this ship off Monte Video, on the 9th February, 1843. Captain Onslow, commanding the *Daphne*, reports to the Admiralty, that "the efficiency of the lightning-conductors was manifested by the electric fluid passing down the main-mast, and through the midshipmen's berth, from whence it made its escape through the ship's side." No inconvenience was experienced.

DIDO, 18.

The general and permanent system of protection from lightning, now under consideration, experienced in this ship a most severe trial, off Java Head, in May last, 1847, in the course of

her passage to New Zealand, a part of the world notorious for the prevalence of severe and terrible thunder-storms.

It appears, by the accounts from the ship, that soon after daylight, there being at the time heavy rain, with little wind, thunder, and lightning, a vivid and fierce discharge fell aloft, in a double or forked current, upon the main royal-mast; one of the branches struck the extreme point of the royal yard-arm, and, in its course to the conductor on the mast, demolished the yard, and tore in small pieces, or scorched up, the greater part of the sail; the other part fell on the vane, spindle, and truck, which last was split open at the instant of the discharge seizing on the conductor. From this instant, however, when the conductor had, as it were, got complete possession of the electrical agency, the explosive action became arrested, and, as stated by the master of the *Dido*, "the discharge freely traversed the whole line of the conductor, from the mast-head downward, without doing further damage." It vanished, as it were, in the sea, effectually conducted through the ship, which, nevertheless, "felt the shock through her whole frame. No one on board was injured;" and the conductor is considered by the officers to be "a complete safety-valve."

So perfect appears to have been the harmless dispersion of this great electrical accumulation, that "the conductor on the masts manifested no appearance that would lead one to suppose that the electrical agency had passed down it." One slight effect of disruptive action, however, occurred, clearly showing that it must have done so, and with no small degree of force: a portion of the leather lining about the main-top-mast-cap appeared to have been scorched and shrivelled in the passage of the charge from the conductor on the top-gallant mast over the topmast-cap. On examination, the copper hinge, or tumbler, usually placed on the cap, for the more perfect union of the conductors on the respective masts, was found missing. It is, however, on a full consideration of the case, nearly certain that this effect resulted from the passage of a branch portion of the charge over the main-royal having fallen obliquely and struck with explosive force on the top-mast-cap; even although the hinge-piece were wanting originally, it is not likely that the leather on the cap would have been shrivelled up in the way described. The whole of the royal and top-gallant mast was evidently involved in the blaze of a great electrical and fiercely-dividing spark, marking, as is usual, the points on which it strikes by violent disruptive

effects. The result, however, is rather satisfactory, as being an evidence of the progress of the electrical discharge on the line of the conductor.

Any one who for an instant reflects on the series of terrible effects of lightning on shipboard, as exemplified in the many instances of ships struck by lightning, cannot hesitate to admit that, but for the transmitting power of the conductors, and general truth of the whole system, the main-mast of the *Dido* must have been shivered into atoms, the ship probably disabled, and some lives have fallen a sacrifice. We have pretty good evidence of this in the case of the *Clorinde*, struck by lightning in the same part of the world in March, 1813, about four miles off Friar's Head, on the east coast of Ceylon. Here the spars were shivered in pieces; only a wreck remained; the main-topmast was literally cut in two; three men were killed and five wounded; and the ship obliged to give up her voyage, and go to Trincomalee for refit.

REMARKS ON THIS CASE.

From the occasionally perilous and variable manner in which lightning falls on ships, it is not always possible to cover protectively projecting bodies such as the yards. In about seven times in ten a concentrated discharge will fall bodily, as it were, on the highest point, and if there be attached to that point a capacious line of conduction to the sea, it will be securely transmitted. But instances are occasionally found in which lightning strikes in a direction more or less oblique to the ship, so much so, as to fall on the jib-boom; as in the cases of the *Sultan* and *London*, and in some others; it may fall immediately upon the deck or into the body of the vessel, as seen in the cases of the *Spartiate*, *Semiramis*, and *Romney*. Such instances, however, are rare. The cases in which lightning strikes the yard-arms, so as to destroy the yard, are also rare, although many are found in which the yards and sails are involved in the general destruction, attendant on the passage of the electrical agency along the spars under an explosive form.

It is now incontestably proved by a large experience, and induction of facts, that metallic bodies have no inherent affinity for the matter of lightning, and exert no active influence whatever in attracting or drawing it aside from its chosen path, except by presenting to it passively a line of less resistance than that in which it is about to move; so far the action of the lightning-conductors we are now exemplifying may be within cer-

tain limits beneficial, in preventing a discharge from falling or continuing in an inconvenient direction; but otherwise, they have really no attractive power proper to themselves in drawing it aside, their action is consequently purely passive; they operate in the way of rain pipes, only in carrying off the electrical discharge which falls on them. They are rather the patients than the agents, and they can only so far defend bodies to which they are immediately applied. It is therefore quite impossible to defend a yard with its attached sail by a conductor on the mast, should the course of the discharge be in that direction, since we cannot dictate to the electrical agency how, and in what way, it shall approach the ship. Such projecting points are, therefore, liable to be assailed as in the present instance, and we cannot possibly protect them except by perfecting the conducting power of the yard which might prove troublesome and inconvenient to carry out as part of a general system, although still possible to be done.

Supposing only the small conducting power of the mast to be in operation, without the metallic conductor, then, as is evident upon these principles, the stroke of lightning would descend at once upon the nearest point, and upon the general body of the mast and sails, shivering and destroying with repeated explosions every thing in its course; for the mast being already a conductor of electricity to a certain extent, will always afford to the electrical discharge an easier path than the air, except under some new and extraordinary circumstances, such as conducting matter in the air itself, or other disturbing causes.

It will be hence seen, that nothing short of a conductor attached to the mast itself could protect the ship in such cases; any temporary kind of chain or rope of wire, appended from the truck and led at a great angle along the backstays over the ship's side, would in this instance of the *Dido* have certainly not defended the mast against the current which struck the yard-arm. The case of the *Hazard*, before referred to, is conclusive upon this point.

Finally, it is to be observed, that the escape of this ship under the circumstances detailed, and the protection afforded by the conductor, is certainly most marvellous and satisfactory, and furnishes an instructive example of the great practical value of experimental and inductive science—the destruction of the royal-yard *without* any conductor attached to it, and the security of the royal-mast *with* a conductor, is a complete crucial experiment, if such were wanting, and speaks volumes.

FISGARD, 42.

A terrific explosion of thunder and lightning is reported to have fallen on the main-mast of the *Fisgard* on the evening of Saturday the 26th September, 1846, whilst at anchor in the Nisqually River, in the Oregon territory.

From a careful review of the official and other documents relating to this case, it is apparent that the ship experienced one of those bifurcated discharges of lightning so frequently observed at the instant of a vivid and intense explosion falling on elevated bodies. The current of lightning evidently divided on approaching the mast, and struck simultaneously on the vane-spindle aloft, and on the lower mast, from three to thirteen feet above the deck. The extremity of the vane-spike was found to have been fused, and the conductor started from the mast in three places, about the point in which the discharge struck below.

The fact is thus recorded in the ship's log:

Saturday, 26th September, 1846, P. M., 7.45.

"The main-mast was struck by lightning, the electric fluid passing down the conductor and out on both sides of the ship, with a very loud explosion, but doing no injury."

The following statement includes the substance of the official letter transmitted by Captain Duntze, of the *Fisgard*, to Rear-Admiral Sir George Seymour, C. B. &c. &c. Commander-in-Chief in the Pacific, and forwarded by him to the Lords Commissioners of the Admiralty, dated Nisqually, Puget's Sound, 30th September, 1846.

On the 26th inst. at 7.45 P. M., the main-mast was struck by lightning—a very vivid flash, succeeded by a loud report, as if a broadside had been fired from each side of the ship, was observed by a senior lieutenant, then on deck, to strike the main-mast. The next morning, on examining the conductor along the mast, the vane-spindle was discovered to have been fused at the point, and blackened one-third of the way down. There were no marks on the conductor of the royal or top-gallant masts, except at the part covered by the cap, where it appeared blackened, and the heads of the nails slightly fused. The conductor on the main-topmast exhibited no marks whatever. The conductor on the main-mast, low down, was found to have been started from the mast in three places—one just above the spider-hoop of the awning, another just below this, and another below this again: (according to the surgeon's

meteorological report, the respective distances were, twelve and a half, seven and a half, and two and a half feet above the upper deck.) The plates of copper forming the conductor were separated at the lowest point, and thrust, as it were, asunder; the edge of the groove in which the plates were laid was slightly rent by the starting of the plates, thereby causing two or three splinters to fall on the deck at the time of the discharge. The electrical current having passed down the main-mast, took the direction of the branches to the bolts through the side,—one leading through the boatswain's cabin, and the other through the midshipmen's berth. The branch conductors in this ship, instead of leading directly to the copper sheathing, near the water's surface, as originally proposed, had been led out above it, to two bands of copper passing down externally over the ship's side; these bands were also started at the ends in contact with the termination of the through bolts, the copper sheathing covering the other extremity of the band was bulged outward. It appears further by other reports, that at the point of contact with the branches and the iron knees within the ship, the metal appeared blackened, as if a slight expansive action had occurred in these points; this is said to have been more apparent in the boatswain's cabin, and may have arisen from an imperfect contact with the iron knee and through bolts. No ill consequence, however, resulted.

Captain Duntze also states that a boatswain's mate, standing abaft the main-mast, on the starboard side, was reported to have been blinded at the moment by the intense light, and to have been knocked down on the deck; one of the midshipmen also on the starboard side, on the main-deck near the mast, felt himself thrust, as it were, aside, but without falling. This is a direct result of expansion on the air. Dr. Dunn, the surgeon of the *Fisgard*, remarks in his report, that there is some difficulty in determining how far the boatswain's mate was struck down by the direct influence of electricity; he appears rather to have fallen down by the concussion and panic of the instant. The senior lieutenant, standing close by, and within three yards of the main-mast, experienced no effect whatever; and it is to be noticed as a remarkable and most important fact, that one of the gentlemen in the midshipmen's berth was leaning at the time of the shock with his elbow resting against the thin batten, or casing, covering the conductor, his head at the same time resting on his hand; so that it was within a few inches of it. He describes the effect as be-

ing similar to the report of a pistol fired close to the ear, but says he did not experience any electrical shock, or any other inconvenience. And this is not a solitary instance of such a result. We find it also apparent in the cases of the *Beagle*, *Scylla*, *Daphne*, and *Fox*, fully showing that the result was in no sense accidental, but may be considered as general.

When it is remembered that the electrical discharge, or at least that portion of it which passed through this branch of the general line of conduction, exploded externally upon the sea with terrific violence, and did actually start the copper bands on the exterior of the ship from their bearings, it is quite impossible not to be impressed with the truth of the general deduction, that the agency of lightning finds its way through the best or least resisting course, without regard to adjacent matter, or any liability to what has been erroneously termed "lateral discharges," and that, consequently, by providing for the agency of lightning a very capacious, continuous, and least resisting course from the highest points of a ship to the sea, protection to the general fabric must necessarily result. In fact, Captain Duntze thus concludes his very interesting and clear official report relative to this case: "*Mr. Rodd, the senior lieutenant, gives it as his opinion, from the severity of the shock, that had it not been for the efficiency of the conductors the main-mast must have been totally destroyed, and much serious damage have occurred, in which opinion I fully coincide.*"

This storm appears to have been of no ordinary kind, several of the pine-trees on the neighboring land were found to have been struck by the electrical discharge and set on fire. The people on shore employed on work for the service of the ship, state that the lightning repeatedly struck the ground in all directions; the ship appeared covered in fire, and the whole atmosphere in a general blaze, with terrific bursts of thunder. According to Dr. Dunn's intelligent Meteorological Report, "Thunder and lightning are not frequent in this part of the world, but it would appear, that towards the end of autumn, when the weather begins to break, the periodical change is ushered in by electrical phenomena." On this occasion the day had been dark and gloomy, with heavy falls of rain. The thunder-clouds were observed by the first lieutenant to gradually approach the ship with frequent discharges of lightning. The effect was such, when the explosion fell on the mast, as to cause a sort of momentary panic, attended by a death-like silence. Some of the seamen who were smoking,

involuntarily took the pipes from their mouths, and laid them down, and the band, which was performing some music at the time on the quarter-deck, suddenly ceased. The first impulse was to open the cocks, and let water into the ship for the use of the engines, under an impression that from the extreme and awful violence of the discharge, something serious must have happened.

Such are the principal facts in the history of this interesting case, and which are most important as furnishing conclusive evidence of the protection to be derived from continuous and capacious lightning-conductors on shipboard, applied in the way we have described. Here is indisputable evidence that as powerful a discharge of lightning as can be well imagined, fell with force directly on the main-mast of the *Fisgard*, which expended all its fury on the conductor, and was, by its protective influence, led securely to the sea, without the slightest damage or inconvenience. We trace it from the points on which it first struck, up to the very sea in which it finally vanished, and we find the ship unharmed and still efficient, amidst the blaze and crash of the most terrible element in nature.

That the lightning fell on the vessel in a double or forked stream is quite apparent: in fact, it was at first supposed, as stated in the Meteorological Report, "that the lower mast *alone* had been struck by a concentrated discharge, but on lowering the copper spindle from aloft it was discovered to have been fused, and a minute red shining globule formed at its extremity." Indeed it was this circumstance alone which led to the discovery of the lightning having also fallen aloft, and of which it furnishes complete evidence. The fact of the lower mast having been struck low down is equally demonstrable by the starting of the copper plates, and by the mast appearing slightly singed in this place; for there is no sufficient reason why such effect should have occurred here more than in any other point above it, except from a direct burst of the electrical explosion upon this part of the mast; but the conductor was examined from the truck downward, and no effects of this kind perceived until within about thirteen feet of the deck. Now it is well known as a law of electrical action, that the immediate points of exit and entrance of lightning into conducting bodies are those in which the most violent expansive effects occur; hence the starting also of the copper bands upon the exterior of the ship at the instant the discharge left the conductor to explode upon the sea. It is also stated in the official Meteorological Report "that several boarding-pikes,

ranged round the main-mast, were displaced, and their wooden stand slightly charred,—further showing that a burst of lightning had occurred about this point. Expansion upon the air is one of the most powerful results of electricity; hence the expansion in striking the mast, low down, would be necessarily severely felt, and would sufficiently account for the fact of one of the officers feeling himself, as it were, "thrust aside, but without falling," which is, in fact, a direct result of expansion, and marks the fact of the lightning falling upon the mast, near the deck. The first lieutenant further states, that at the time the lightning struck the ship he was sensible of three distinct effects. *First*, a vivid and intolerable glare of light: *secondly*, a sharp, ringing, crashing sound, almost indescribable, and which he characterizes as the explosion of lightning in the water; *thirdly*, the terrific burst of thunder over his head: all these followed close upon each other, with a scarcely distinguishable interval of time between them. Now, it is not improbable that these two latter effects may have resulted from the fact of the double discharge—the one striking a little before the other; first on the mast, low down, close to the deck; the other at the royal-mast head, 200 feet in the air, and which would account for the phenomena in question. The whole series of results, therefore, confirm the conclusion that the ship was struck by a divided, or by two streams of lightning, one part falling on the spike, at the mast-head, the other low down, near the deck.

We have many instances of ships struck by forked discharges of lightning, and by discharges which have fallen low down on the mast; and this last result, whether it proceed from a divided or single stream, no conductor of the ordinary kind can meet; a vessel will be always open to damage in this way so long as the masts themselves, together with the hull, are not made perfectly conducting, throughout.

The following extracts of two letters, one from the senior lieutenant, Mr. Rodd, the other from Lieutenant Dyke, furnish valuable notices of the phenomena we have been discussing:—

"Perhaps few men (observes Lieutenant Rodd) had such an escape as I had on the 26th of last September, when lying moored off the Nisqually River. A violent thunder-storm commenced about six, P. M., accompanied with heavy rain, lightning gradually approaching the ship; as I was speaking to one of the men, relative to the lightning-conductor, the electric fluid burst over our heads, striking the main-mast and passing

down the conductor, within three yards of my body. A seaman, who was almost touching me, was temporarily blinded by the vivid light, and fell on the deck. The electric fluid passed off by the conductors on each side of the ship, into the water, with an explosion beyond all description; it stunned every one on board. Thanks to the lightning-conductors, with which every mast is fitted, no danger was sustained."

Lieutenant Dyke says:—

"We were struck by lightning about eight, P. M., on Saturday, the 26th September. The crash was most awful—just as if five hundred broadsides had all gone off together. We had been exercising great guns that day before the Indians, and were already half stunned by the repeated discharges; but, it struck us all, how ineffectual had been our attempts to make a noise when Nature poured forth her dreadful artillery! The electric fluid appears to have struck the vane-spindle; it then passed harmlessly down the conductor until it reached a point where the boarding-pikes are stowed round the main-mast; here one plate of the conductor was started from the other, after which it passed out on both sides of the ship, causing a good deal of fear, but no danger. We did not trace any portion of the discharge through the ship's bottom.

"No greater proof of the value of these conductors can be produced. I was on deck some time before we were struck; there was then occasional sheet-lightning in the distance, which we took no notice of, as we had observed it for several nights before; there was nothing that would have led us to have got the old kind of conductor up from below, and we were told that lightning in the Oregon was very rare."

The complete protection of this frigate, on a foreign station, from the destructive agency of lightning, being by these different documents made peculiarly clear and comprehensive, it may not be further uninstructive to notice briefly the consequences of a similar discharge of lightning on the *Phaeton* frigate of 46 guns, in September 1824, whilst at anchor in the Bay of Gibraltar; and which is, perhaps, the more worthy of remark, inasmuch as the *Phaeton* was a frigate similar to the *Fisgard*. The period of the year, and even the time of the day, in both cases were the same. In each instance, also, the ships were at anchor near the shore, the thunder-storm came off the land, and a subsequent especial report was made from the captains to their respective admirals, and by them transmitted to the Lords Commissioners of the Admiralty.

The log of the *Phaeton* runs thus:—

"Tuesday, 14th Sept. P. M. eight. Fresh breezes and cloudy, with lightning and thunder. Ship struck by lightning, which rent the foremast, fore-topmast, top-gallant, and royal-mast; set fire to the fore-topmast-head and fore-top-gallant and lower studding-sails. Beat to quarters, and extinguished the fire."

The 14th and 15th were employed in making good defects: the foremast was cut off sixteen feet above the deck, and a spare main-topmast rigged as a jury-foremast; after which the ship was obliged to leave her station, and return to Portsmouth for refit.

The following is an extract from Captain Sturt's letter to Admiral Sir George Martin, dated on board H. M. ship *Phaeton*, Spithead, 21st October, 1824:—

"From seven to eight, P. M., it blew extremely hard, in squalls, with vivid flashes of lightning, which seemed to approach the ship; a few minutes before eight there was observed a condensed black cloud, evidently charged with electricity, to glide along the side of the rock, and, directing its course towards us, exploded at ten minutes past eight, with a terrific crash, directly over the *Phaeton*, striking first the fore-top-gallant-mast; it descended down the top-mast to the fore-mast and bitts, all of which were shivered in pieces, and set on fire, together with the small sails in the top, and the top-mast studding-sail in the larboard rigging.

"The electric matter likewise struck the main-top-gallant-mast, came down the signal-halliards, which were burned to cinders; and then attracted, as I conjecture, by one of the carronades, it escaped out of the port. The very hearts of the masts were torn out, and five of the iron hoops on the fore-mast partially melted and torn asunder.

"Several men were struck down, and lay for some time in a state of stupor."

Such were the effects of a discharge of lightning on the *Phaeton*, similar to that which fell on the *Fisgard*, proving incontestibly the truth of the concluding remark in Captain Duntze's letter, that, "but for the efficiency of the conductors, the main-mast of the *Fisgard* must have been totally destroyed, and much other serious damage have occurred."

Any unbiassed person, therefore, who considers attentively the history of such cases of lightning, must reasonably admit that they have a conclusive and important bearing on the interests of the Navy; and evidently show that, by a proper

arrangement of metallic conductors, ships may certainly be guarded against the destructive effects of an element which, as shown by the records of Her Majesty's ships for a long series of years, have continued to deprive the country of the full services of its fleets, destroying its sailors, and wasting its treasure; thereby frequently placing the national interest in a critical position. If, in time of war, the *Fisgard* of 42 guns had been disabled and had lost her main-mast on a foreign station, such as the Oregon, the consequences might have been most serious, to say nothing of the difficulty, inconvenience, and expense of supplying a new mast at so great a distance from England.

FOX, 42.

The "Ceylon Times" describes a terrific storm of thunder and lightning as having occurred at Colombo on the 5th of April, 1847, during which H. M. frigate *Fox*, Commodore Sir Henry Blackwood, and a merchant-vessel near the *Fox*, called the *Bittern*, were struck by the electrical discharge. "In the former ship, the electric fluid passed safely off by the lightning-conductors." With reference to the *Bittern*, it "entered the fore hatch, tearing away part of the casing of the main-mast," &c. &c.

No especial report appears to have been made by the Commodore on this case of protection, but the following is an extract from the ship's log, showing that the protection had been most complete:—

"*Fox*, at single anchor, Colombo, Monday, April 5th, 1847.

"Wind S. W. 2h. 30m. P. M. Down top-gallant yards.

"Wind S. E. 4h. 5m. P. M. Squally, with heavy rain, thunder and lightning.

"Wind S. W. 5 P. M. Lightning struck the main-mast, and passed visibly down the conductors, through the midshipmen's berth and commodore's steward's berth, leaving a mark in the latter, but without doing any damage."

MINDEN, 74.

The *Minden* was completely fitted with the permanent conductors at Devonport, in 1841, being destined for service in India and China, where storms of lightning are known to be extremely severe. . . The ship, since the time of her sailing from England, in 1842, has been frequently exposed to such storms, but without receiving the least injury.

Captain Quin, reports, that on the 19th July, 1842, whilst in the Straits of Malacca, the ship experienced a severe squall of rain and wind, with thunder and lightning. "The forked lightning fell on the masts and played about the conductor in a truly awful manner." Such, however, was the rapid transmission of the electrical discharge, that no heavy explosion ensued, which Captain Quin "attributes to the admirable adaptation of the protector."

On the 8th and 9th August, at Hong Kong, a sort of typhon set in with "ugly appearances—rain, thunder, and lightning." Ship at anchor—yards and top-masts struck—jib-boom and spritsail-yard in, per signal. Thunder, sudden and heavy; lightning, vivid beyond description. According to Captain Quin's characteristic remark, "it was lightning indeed." Ship said to have been struck on the main-mast. Captain Quin states, that an opium ship, named the *John Barry*, in the immediate vicinity of the *Minden*, had her fore-mast shivered all in pieces. One of the crew of the *Minden*, since arrived in England, states that the concussion of the thunder was such as to convey, to those below, the idea of the shock of an earthquake.

Mr. Cook, the purser of the ship, in a letter, written from Hong Kong, and which appeared in the public prints, thus describes the phenomena:—

"The lightning last night was heavier than I ever saw it before; two flashes struck the *Minden*, and played about the conductors for a few seconds, conveying a stream of fire through the ship, awful to behold. A frizzing noise was distinctly heard, and I have no doubt but that we should have received serious injury had we not been protected by our conductors. I have been informed that the lightning struck several merchant vessels, killed four men, and wounded some others. We are now lying with the fore-yards and top-masts struck."

Besides the protection of the *Minden*, in this tropical storm, we find the *Cornwallis*, 74, Vice-Admiral Sir W. Parker, also successfully defended against the heavy discharges of thunder and lightning which enveloped the ship. Captain Richards states that the conductors, fixed in the masts, completely transmitted the bursts of lightning which fell on the spars. Thus we find two line-of-battle ships on a very critical service, on a foreign station, perfectly secure in a thunder-storm, which on other similar occasions had caused very great devastation, and which did even then shiver the masts of merchant-ships near them, and killed several men. It is not difficult to imagine

the serious consequences which might have ensued to the public interest if either or both of these ships had been disabled at Hong Kong, during the late Chinese war, in which they were engaged.

RACER, 18.

The *Racer*, commanded by Captain A. Reed, was struck by lightning, at the Bucco, in the Rio de la Plata, on the 27th of February, 1844.

The electrical discharge fell on the truck of the fore-top-gallant-mast; the vane-spindle, which terminates the conductor, being down for repair. It melted a portion of the copper band round the truck, and then getting hold of the conductor, fixed in the mast, was immediately dispersed, without inconvenience or damage. Captain Reed thus relates the circumstance:—

"About 4.30, A. M., during a heavy storm of thunder and lightning, the lightning was distinctly seen to run down the fore-mast; and upon removing the truck (which I have now in my possession,) it was quite evident, from a part of the copper rim round the truck being fused, that the lightning had entered there, passed along a bolt of one of the sheaves, and so communicated with the conductor on the mast, which carried it safely off. We have shown the truck to many persons, who all speak highly in favor of the conductors."

This is a direct case of the dispersion of an electrical discharge, which actually melted the metallic band in the place on which it first struck.

SCYLLA, 18.

This sloop was struck by lightning in the West Indies, August 6th, 1843, at 7.50, A. M. The lightning fell on the mast, and it appears by the log, was most effectually carried off, without any damage to the spars or hull. Captain Sharpe, who commanded the *Scylla*, thus describes the circumstance:—

"On the morning of the 6th August, 1843, lat. 24. 3 N., long. 69. 12 W., the *Scylla*, at about 8, A. M., was struck by lightning, attended with a heavy clap of thunder, which shook the ship to her kelson. The greater part of the morning watch had been one continued and heavy rain, the weather threatening and unsettled, sky overcast with dark clouds, wind un-

steady, heavy thunder and lightning, both sheet and forked, and frequent explosions very close to us."

The ship was struck from a cloud densely charged with electric fluid, which overhung the masts; it was raining furiously all the time.

"The course of the lightning was from the main-truck down the main-mast, escaping through the ship, by the various conductors connected with the mast for that purpose." Captain Sharpe further observes, "There can be little doubt that our spars were saved by the conductors, and from their being fixed, I consider them preferable to any I have ever seen."

This seems to have been an extremely powerful discharge, some of the butts of the copper-plates in the top-gallant-mast were started by it, and in one place buckled up at the edges; some of the fixings also were shook and loosened. Captain Sharpe states that "no other mast was touched, or felt the least effect from the shock," and that "the top-gallant-mast, on which this occurred, was not fitted by the dock-yard in England, but was prepared at Port Royal," where the most improved method of applying the conductors to the spars could not as yet be known. The circumstance may be considered, in an experimental point of view, as a very fortunate one, since it shows how violent a shock the copper-plates could discharge, without any heating effect being produced on them, and without any kind of inconvenience being experienced in the hull of the vessel, or by the conductors themselves, when properly secured.

Mr. Welsh, the carpenter of the ship, and whose duty it is to inspect the masts, states, by permission of his captain, that

"On examining the conductor, after the ship was struck by lightning, I found it had started from a butt, about three feet below the truck, at the main-royal-mast head; it was again replaced in a few minutes," that "neither the ship, nor the mast, received any hurt or damage from the flash or the fluid," and gives it as his true opinion, "that had it not been for the conductors, the mast, if not the ship, must have sustained a serious injury."

It appears also by the ship's log, that such was the excited condition of the whole mass of the ship, and the air immediately under the thunder-cloud, that "various parts, such as the chain cables, coppers, &c. exhibited symptoms of electricity;" it also appears by the log, that "the ship having shortened sail, 6.30, A. M., to a heavy squall from S. W.," was, "at

7.50, during a squall from N. W., struck by lightning," in the way above described. At 8.20, that is, within half an hour, they "made sail" again, and the ordinary duties of the ship went on as if nothing unusual had occurred.

Here, then, we have an instance of a ship rendered perfectly secure from the effects of lightning in the focus of a tropical thunder-storm, and under circumstances of a very threatening and dangerous kind; and which, as appears by the records of H. M. Navy, have in a great variety of similar instances been productive of the most fatal consequences.

TALBOT, 20.

In July, 1842, H. M. ship *Talbot*, having just completed her equipments at Sheerness, was proceeding to sea, when she encountered a thunder squall near the Nore. A dense cloud poured forth its lightning, attended by a crashy peal of thunder. The Captain, Sir Thomas Thompson, observed it strike upon the conductor, on the main-mast, by which it was instantly discharged without damage or inconvenience: at this time the ship was under weigh, and the men employed upon the ropes and sails, as usual on such occasions.

Communicated by Lieutenant F. Harper, of H. M. ship *Daphne*, at the time of some electrical experiments on the *Daphne*, before the Lords of the Admiralty, at Chatham, August 17, 1842. Lieutenant Harper, was at the time alluded to, in the *Talbot*.

CONCLUDING OBSERVATIONS.

In reviewing these instances of the preservation of certain ships of the British navy in thunder-storms, it is impossible not to be struck with the concurrence of various individuals in their accounts of the phenomena which they witnessed; and it is impossible not to be impressed with the importance of the fact, that these statements have been made by officers in H. M. service, at intervals of several years, quite unconnected with each other, and quite uninfluenced by any personal interest. The statements are made in plain but intelligible language, describing just what the observers witnessed, according to the common acceptation of the terms which they use, neither more nor less. Nothing, therefore, in the shape of evidence can be more perfect.

There are a few interesting facts developed in the history of these cases, which it may be worth while briefly to notice.

First.—The electrical discharge is said to have been attended by a peculiar whizzing noise, such as that produced by the escape of steam or boiling water. This phenomenon has been also noticed in other instances of thunder-storms at sea. Thus in the case of H. M. brig *Bellette*, 18, struck and damaged by lightning in the West Indies, in May, 1825. Captain Leath, who commanded the brig, says, "As the lightning shot towards the earth, it caused a noise similar to the whizzing of musket-balls." In this case some of the spars were shivered in pieces, and thirty-six men struck down on the deck, five of whom were seriously injured.*

Secondly.—The observers agree in stating, that the discharge is accompanied by a luminous stream, as if the lightning were running down the conductor. This phenomenon was witnessed so long since as the year 1777. A heavy stroke of lightning fell on the conductor of the Tower of Sienna, and several persons noticed upon it "a long and regular train of light."†

* See "Nautical Magazine," for March, 1844, p. 162.

† "Tilloch's Magazine," vol. viii. p. 318.

We have a satisfactory illustration of this phenomenon in the fact of a metallic wire appearing luminous when transmitting a progressive and intense current of artificial electricity thrown upon one of its extremities. It may, in fact, be caused to present to the eye the train of light, or other luminous appearance, termed by the observers, "lightning running down the conductor."

Now, it is to be here especially understood, that one of the great results of a pointed capacious lightning-conductor, is either the mitigation of the dense shock altogether, or otherwise the reduction of it within manageable limits. If we attempt to discharge a powerful electrical battery by means of a pointed wire, two-thirds of the accumulation will, as is well known, frequently pass off before the explosion can be effected; and it will pass off as a progressive current, occupying a sensible portion of time. This is what really takes place in the action of an efficient lightning-conductor upon an intense atmospheric accumulation. Before the explosion, which we term thunder and lightning, actually occurs, the conductor commences its action, and anticipates the violence of the explosion by carrying off a very considerable portion of the accumulation in an intensely progressive current; it is at this instant the luminous appearance which the observers describe, takes place. If the conductor can, in its transmitting effort, keep pace or contend with the growing intensity of the accumulation, no explosion, such as we denominate lightning and thunder, takes place at all; and of this we have numerous instances.* When, however, the redundant electricity of the thunder-cloud prevails, then a burst of the whole remaining charge finally occurs, and the conductor is exposed to the operation of the accumulated spark; the two actions follow closely upon each other, and are hence confounded together; we perceive the luminous effect of the first, but the second is too instantaneous to track by any result, except the impression of a vivid flash of intense light. In fact, a shock of electricity, transmitted by a conductor, moves, or is propagated through it, at the rate of 576,000 miles in a second of time; the duration of the light of the spark is about the 1,552,000th part of a second. This has been satisfactorily proved by Wheatstone's most ingenious and beautiful experiments.† The eye may receive an impression of light even from a flash enduring for so small a space of time, but it cannot track the course of an agency moving with such incredible velocity.

* See *Minden*, page 28.

† Philosophical Transactions.

The stream of light thus observed upon a conductor, about the time of a shock of lightning falling on it, is of a perfectly harmless character; and must be distinguished from the actual presence of the electrical agency itself. We may cast percussion powder, and other sensitively inflammable matter, upon a wire thus luminously affected, without any ill consequence: the danger, in all cases of electrical discharge, is the repeated explosive action of the electrical agency itself in forcing its way through badly conducting matter.

Thirdly.—The luminous effects of a heavy discharge of lightning upon the mass of the air surrounding the vessel, are again occasionally described as apparently enveloping the ship in flames, or some form of expression of this kind.

This is again a pure result of common electrical action. If a dense explosion be transmitted over or through badly conducting bodies, or be caused to pervade them, they will frequently emit light, or glow with light, and the light will sometimes continue upon these bodies after the discharge has vanished. It is difficult to conceive an action such as that resulting from a discharge of lightning upon a conductor attached to a ship or building, without at the same time perceiving that the whole electrical condition or state of the particles of the surrounding air would be necessarily affected electrically, and give rise to those luminous effects so frequently observed in the passage of dense electrical sparks between rounded conductors. Two small balls may be so placed as to cause the intervening air to appear, by the discharges from a very powerful electrical machine, full of light, and the balls enveloped in electrical fire; like other phenomena of this kind, the luminous effect is of a harmless character.

We find, in accordance with this result, an instance in Rozier's Journal, vol. xxii., of lightning falling on the conductor of a powder magazine, in Silesia:—"The flash was seen to leave the cloud and strike upon the rod; it appeared to envelop the whole building in electrical fire;"—a form of expression very similar to that employed in the history of the preceding cases.*

Fourthly.—The violent concussion the observers describe, so common in the case of the electrical discharge striking elevated bodies, and the simultaneous descent of the lightning, with the crash of the thunder, is particularly characteristic. "I could perceive no interval of time between the flash and

* See cases of the *Beagle* and *Dryad*.

the thunder," observes Mr. Bonham, in his account of the *Actæon*; thus, also, Mr. Sadler, with respect to the *Asia*, 84, speaks of "the sudden flash, and *instantaneous* clap of thunder." Other observers speak of the concussion, as if the broadside had been fired, which is another characteristic of the electrical discharge falling on ships. Thus, in the account of the lightning which fell on the *Fisgard*, the concussion is compared to the simultaneous fire of five hundred broadsides. When the *Trident*, 64, was struck and damaged by lightning, in October, 1803, the log states that "the electrical discharge burst over the ship with a crash as if the main deck guns had gone off." The same thing is stated in the instance of H. M. ship *Clorinde*, 44, and *Egeria*, 20.—*Naut. Mag.*, June, 1843, p. 401, November, 1843, p. 742, and January, 1844, p. 28.

Fifthly.—It is important to notice the fact, that in the case of the *Scylla*, lightning, both sheet and forked, exploded near the ship, without striking her at all. This has been observed in several other cases. For instance, H. M. ship *Southampton*, 50, was, on the 30th June, 1842, exposed to a tropical thunder-storm. The master of the ship, Mr. Martin, states, that "it lasted from 10, P. M. to 2, A. M., the thunder and lightning being quite incessant. The lightning struck the sea close to the ship, but no explosion occurred on the conductor." A similar case occurred in H. M. ship *Sapphire*. See Report and Evidence, &c., p. 93. In ships, also, without conductors, we find lightning often striking upon the sea near them, as in the case of H. M. ship *Arab*, 22. The log describes the electrical discharges as "thunderbolts flying about the ship, two or three of which fell in the water, within a cable's length of the ship." All this is of practical value, inasmuch as it clearly proves, that the conductors only operate in carrying away the lightning when it falls on them; but they do not necessarily draw it down on the masts. We have seen how well they performed this duty in the *Fisgard*, *Scylla*, and others. When, however, the discharge fell on the masts of the *Arab*, in the case just alluded to, which at last it did, the spars were shivered in pieces, three men were killed, and six men wounded.—*Naut. Mag.*, June, 1843, p. 394.

Upon the whole evidence, therefore, there cannot be the least doubt of the electrical discharge, in its most severe form, having fallen on most of these ships in the way described, and of their having escaped the damage usually attendant on it; and it is also evident, that the electrical agency was deprived

of its explosive action from the instant of its reception by the conductor aloft, or other point on which it first struck: from that instant, it existed no longer under the form of lightning. Its terribly expansive force, its irregular and explosive course, its inflammatory effect on combustible bodies, so commonly experienced in ordinary cases, are here unknown; and it may hence be fairly inferred, that by means of the system of electrical conduction carried out in these ships, the British Navy, and shipping generally, may be effectually secured against the ravages of one of the most destructive and fearful elements of nature.

On a comparison of these few cases of protection with the numerous instances in which damage has occurred, the amount saved by the conductors would not be far short of £20,000, to say nothing of more vital considerations. This may be easily shown in estimating the destructive effects which might have ensued, by those which have actually resulted under similar meteorological circumstances. Thus the case of the *Fisgard* may be associated with that of the *Phæton;* the instance of the *Scylla* may be compared with the case of the *Arab*, as above shown; the case of the *Asia*, 84, is parallel with the case of the *Audacious*, 74, struck by lightning whilst at anchor off Flushing, in August, 1810; the circumstances of the storm, winds, &c. being nearly alike, and so of the others. Now the cost of refit of these ships is known: the refit of the *Audacious*, for example, including a new main-mast, amounted to a considerable sum, certainly not much less than £3,000, without taking into account the detention of the ship, and the loss of her services for six weeks.

The reader is referred to the pages of the Nautical Magazine, from June, 1843, to June, 1844, for a history of damage by lightning to the British navy, as taken from the official journals of the ships.

The cases of the *Surinam*, 18, *Trident*, 64, *Clorinde*, 44, *Eagle*, 74, *Lowestoffe*, 36, *Thisbe*, 36, *Theseus*, 74, and some others, furnish very marked illustrations of the dreadful havoc produced by lightning, in forcing its way through badly conducting matter.

In the case of the *Surinam*, the main-mast was shivered and in its fall stove in the deck, and destroyed the cabins beneath; signals of distress were made, and the ship was nearly lost on the French coast. In the case of the *Trident*, the electrical discharge is said to have burst forth from a dense black cloud right over the ship, as in the instance of the *Scylla;* it shiver-

ed the spars of the main-mast, filled the ship with smoke, and, with a suffocating smell of brimstone, burned four men severely, and so disabled the ship that she was taken in tow by one of the squadron, for two days. The *Thisbe* and *Lowestoffe* were left mere wrecks on the sea; the *Eagle*, 74, was in danger of being burned; and these instances may be taken as mere samples of the mass of damage recorded in all the other cases.

It may here be again observed, that the electrical agency, whatever it be, only assumes the conditions of what is commonly termed thunder and lightning, when it is determined in its course through badly conducting matter, such as air. In pursuing its course through bodies which offer comparatively little resistance, such as the metals, it becomes robbed, as it were, of its explosive power, and exists no longer under the form of lightning; the great body of the discharge is reduced, in fact, to the condition of a comparatively quiescent current, and little luminous effect attends it, except an evanescent electrical light, of a perfectly harmless character. The common notion that lightning is attracted towards, and brought into a ship, by conducting bodies, will be seen by these cases to be quite unfounded: where the conductor is perfectly continuous and capacious, from the highest points to the sea, the explosive action, constituting lightning, vanishes from the instant the electrical agency strikes on the conductor. Instead, therefore, of lightning being drawn down into the body of the vessel, and deposited there, as many have erroneously supposed, it is virtually prevented from coming into the ship at all.

In conclusion, it may be as well to explain what is to be fairly expected from the system of electrical conductors we have been practically considering, and what is not.

It is certainly to be expected that the conductors should provide against damage from all those violent shocks of lightning falling within the common experience of mankind; such, for example, as those which have occurred in two hundred and twenty instances of ships of the Royal Navy alluded to in the following pages as having been struck and damaged by the electrical discharge; and that the system is adequate to this is as certain as any very high degree of probability or assurance, depending on a large experience or induction of facts, can attain. The conductors have been now employed, to a greater or less extent, in ships of the Royal Navy, during a period of full seventeen years and upwards, and these have been exposed to severe thunder-storms in almost every climate

and latitude in which the effects of atmospheric electricity are most to be dreaded. In India, in China, the Pacific, Halifax, and the West Indies, and in more northern latitudes;—in all these different seas has the efficiency of the system been critically and severely tested. Taking a period of about sixteen years, viz., from 1830 to 1846, during which we find this system of electrical conduction carried out, first in ten or twelve ships, and latterly in nearly the whole Navy, not a single casualty from lightning is to be found in any one of them, nor have the ships been struck by lightning in anything like the proportion of other ships not so protected, and within a similar period of time. In cases where heavy electrical disturbances have enveloped the general mass of the vessel, and the electrical discharge has fallen on the masts under the form of thunder and lightning, it has been either parried by a rapid dispersion, or by an immediate transmission, as may be seen in the preceding cases. Of the large number of ships fitted with these conductors, not above ten instances have occurred in which they have been actually struck by lightning, and then without inconvenience or damage to the vessel, although very many instances are recorded of protection in furious thunderstorms by the influence of the conductors in rapidly dispersing intense accumulations.

Take now a similar period of time in which ships of the navy *not fitted* with such conductors have been on service, viz., from 1824 to about 1840, and it will be seen, that at least forty-five ships, averaging full one-fourth of the whole number of vessels annually at sea, have been struck by lightning, and terribly damaged, within that time; and which, it is to be observed, includes full ten years common to both periods.

Hence it may be fairly inferred, that if the two hundred and twenty ships of the Royal Navy, before referred to, as having been struck and damaged by lightning at various times, had been provided with this system of electrical conductors, the great mass of destruction which ensued would have been avoided, and many lives would have been saved.

On the other hand, it is not to be expected that this system will guard completely against every possible result of electrical discharge, be the circumstances what they may, or against any of those equivocal atmospheric phenomena occasionally found to occur in conjunction with electrical action. Nor would it be reasonable to suppose we could effectually guard against electrical disturbances in the atmosphere, mixed up with certain convulsions of nature; nor against those discharges which

assume the form of meteorolites, in which case it might be immaterial whether a ship were provided with lightning-conductors or not; nor is it to be imagined that any system of conductors in ships can quiet all those minor electrical actions dependent on the excited state of the mass of the atmosphere and the general body of the vessel immediately under the influence of a thunder-cloud, and which will frequently give rise to a luminous phenomenon of a perfectly harmless character; nor can it obviate that terrible concussion and expansive action produced on the air in case of the thunder-cloud breaking upon the masts, and which, in common with similar mechanical forces, such as the discharge of cannon, will be generally felt severely, and may rupture or tear asunder, or shake in pieces, frangible kinds of matter. Against this no lightning-conductor can provide. A conductor can only insure protection by disposing of the electrical discharge *itself*, which is the great source of destruction, and dispersing or conveying it away under the form of a non-explosive current.

Finally, it must never be lost sight of, as a most important feature in this discussion, that the mast of a ship, with the metals about it, is already a conductor of electricity, and will commonly afford to the electrical discharge an easier course to the sea than that through the air, and will so far, by its position alone, tend to determine a stroke of lightning upon the body of the vessel, and no human means can prevent it. By attaching, therefore, a capacious line of metal to the mast, we enlist, as it were, into the service, the conducting power which the mast already possesses, and add it to that of the metal. Thus we convert that into a source of protection which otherwise might prove a source of danger.

Taking, then, the common course of nature, as displayed in ordinary cases of ships struck and damaged by lightning, we are quite warranted in concluding, as a general truth, that a vessel armed with a system of protection, such as will render the whole mass generally non-resisting or passive, as regards the progress of the electrical discharge, would in no case experience any material inconvenience or damage; and, supposing any slight extraordinary casualty or exception to this general deduction to be within a calculable probability, still we may rest assured, as a positive certainty, that a trifling casualty occurring in any ship having such conductors, would amount to severe damage, and perhaps destruction, without them.

PLYMOUTH, November, 1847.

Having now given the principal instances of protection to ships furnished with Harris's conductors, the author gives particulars of two hundred and twenty cases where ships of war were damaged. He prefaces this list by the following notice:

[Notice.—It is to be especially observed, that this Record does not profess to comprise all the ships of the British Navy damaged by lightning since the commencement of the war, about the year 1793, but only such cases as have come to the author's knowledge through the kindness of his many naval friends and acquaintances, and which, through the liberal permission of the Lords Commissioners of the Admiralty, have been fully verified by a long and patient investigation of the official journals. From the frequent notices with which the author still continues to be favored, and the repeated accounts of thunder-storms found in these journals, it is highly probable that almost every ship on the lists of the navy, from the above period upward for full forty years, has, at one time or another, suffered in some way from this source of danger. It is not always possible to trace, through the bustle and turmoil of a long naval war, and naval evolutions and circumstances generally, authentic accounts of such damage; indeed, it is not always mentioned; while in duplicate logs of the same ship, it is sometimes mentioned in the one, and omitted in the other. It is, however, quite apparent, from this record alone, that the inconvenience to the public service, and to the navy especially, in consequence of the destructive agency of lightning, has been not only of very considerable magnitude, but of serious national importance.]

GENERAL DEDUCTIONS.

First.—The total number of instances of damage done by lightning in the Royal Navy, as given in the record, amounts to two hundred and twenty. They comprise 87 ships of the line, 55 frigates, 78 sloops, and other vessels. In these instances, there were damaged or ruined 164 lower masts; of which 117, or more than two-thirds, were lower masts of line-of-battle ships and large frigates; 152 topmasts, of which more than two-thirds were topmasts of liners and frigates. The destruction in spars, therefore, is very considerable; of 64 lower masts of ships of the line struck by lightning, 48, or about three-fourths, were ruined as masts, and replaced by others.*

Second.—It can be shown by official documents, that at the time when the greater part of these masts and spars were disabled, the cost of a line-of-battle ship's lower masts amounted at one time to £1,200 each, and upward; whilst the contract price for spars only, for topmasts, was as high as £200 each; other spars in proportion. The expenditure, therefore, to meet this great amount of destruction, must have been something very considerable, especially when we take into account the circumstance that masts and spars were supplied to ships for refit on foreign stations. If we further consider the money sunk on the general refit, rigging, sails, and other contingencies, it may be shown that during the war from 1793 to 1815, the country did not expend much less than £5,000 per annum on account of the destruction of material alone, upon about

* In this deduction nothing under 32 guns has been classed as a frigate; which accounts, with some additions to the list, for an apparent disagreement with a former analysis, in the Nautical Magazine for 1843, where more ships were included under the class of frigates. Here we have fewer ships classed as frigates, and more as sloops or corvettes; the frigates of former days being now so considered. The general results, however, are the same very nearly, as to the total number of spars damaged or destroyed upon the whole number of ships.

133 cases only, to say nothing of the loss of the services of the ships, the cost of their detention, &c. Hence it may be inferred, that upon *all the instances which have probably occurred*, together with every contingency, the loss to the Treasury annually, on account of damage in the navy by lightning, must have been something very serious. On a moderate computation, as given in the Nautical Magazine, volume for 1843, it may be fairly set down as having been not less than from £7,000 to £10,000 annually in war, and from £3,000 to £5,000 in peace; to say nothing of the seamen hurt and killed, and the loss of the services of the ships at critical periods.

Third.—In about forty of these two hundred and twenty instances, or between one-fifth and one-sixth of the whole number, the ships were set on fire in some part of the masts, sails, or rigging, and were occasionally placed in great peril.

Fourth.—In about seventy of these cases, that is, one-third of the whole number, nearly, some of the crew were either killed, wounded, or severely hurt or knocked down on the decks, twenty and thirty at a time. The numbers actually killed, or severely hurt or wounded, amount to ninety killed, and about two hundred wounded.

Fifth.—By a careful analysis of the phenomena, it may be further shown—

1st.—That in two out of three times lightning strikes upon the top-gallant or highest masts.

2d.—In about one in five times upon the topmasts, or next highest points.

3d.—In about one in seven times upon the lower masts, or next highest points.

4th.—In about one in fifty times upon the hull directly.—From which it may be inferred that the electrical discharge is frequently determined toward a ship in directions more or less oblique to the masts and hull.

Sixth.—It may be further shown—

1st.—In about two instances out of three a ship is struck by lightning on the main-mast only.

2d.—In about one in five on the fore-mast only.

3d.—In about one in twenty on the mizen-mast only.

4th.—In about one in eighty on the jib-boom.

5th.—In about one in two hundred on the extremity of the yard-arm first, without including the mast.

6th.—In about one in six instances the yards and sails are struck, together with the spars.

Several cases are found in which the fore and main-masts are struck simultaneously, exclusive of the mizen-mast; also of the main and mizen-masts, exclusive of the fore-mast; and even of all three masts being struck; but no instance appears of the fore and mizen-masts being assailed by lightning at once, exclusive of the main or centre mast.

Seventh.—We also learn—

1st.—That one in sixteen times nearly, the electrical discharge has fallen on the ships in a divided or forked stream, producing a sort of double, and in some cases a treble, discharge.

2d.—In about one in twenty times the discharge has fallen very oblique in regard to the masts and hull.

3d.—In about one in twenty-seven cases, ships have been struck by repeated discharges in the same storm, from two to five times within the short space of an hour.

Eighth.—Four cases occur in which ships have been struck by lightning on the fore-mast, a temporary conductor being appended to the main.

Nine instances are found in which a temporary form of conductor, appended as rigging to the main-mast, did not, from some cause, afford the required protection.

Ninth.—Such are some general and important deductions arrived at on a careful analysis of the two hundred and twenty cases of ships of the Royal Navy struck and damaged by lightning. Many more might have been adduced, of perhaps equal importance. For it may be seen, that shipwreck in every possible form is contingent on damage by lightning; and it is hence not improbable, that many ships, whose loss is now certain, from the time they have been missing, may have perished from this source of danger. Thus, it is known that the *Peacock*, 18, disappeared in 1814, on the coast of Georgia, immediately after a severe thunder-storm; and the *Resistance*, 44, according to Steel's List of the Navy, Naval Chronicle, James, and other naval historians, was actually blown up by lightning, 14th June, 1798, in the Straits of Banca.

PREFACE

TO HARRIS'S WORK ON THE NATURE OF THUNDER-STORMS.

The fact of electrical conduction by metallic substances having been so long and so well established, any further discussion of the application of this principle to the purpose of protection against lightning may possibly appear to persons, conversant with such subjects, as in some degree superfluous. The damage, however, which so frequently occurs in thunder-storms, attended as it is with loss of life, and with serious inconvenience to the best interests of the country, may be fairly adduced as a sufficient reply to such an opinion.

"The beautiful spire of St. Martin's church, in London, has been recently rebuilt, at a cost of full one thousand pounds sterling, in consequence of an explosion of lightning, which fell on it in July last. Brixton church, near London, had also to undergo extensive repairs, rendered necessary from the same cause. In January, 1841, the spires of Spital-fields and Streatham churches were struck by lightning, and the latter nearly destroyed: and in August of the same year an electrical discharge shook the spires of St. Martin's and St. Michael's churches, at Liverpool, both modern edifices of a costly and elaborate construction. In January, 1836, the spire of St. Michael's church, near Cork, was rent by lightning down to its very base; and in the following October the magnificent spire of Christ church, Doncaster, was almost totally destroyed by a similar discharge.

Thus, in the United Kingdom alone, and within the short space of five years, we find at least eight churches to have been either severely damaged or partially demolished by lightning; to this list of casualties may be added the fine old church of Exton, in Rutland, which, according to the public

journals, was in great measure destroyed in a thunder-storm, so lately as the 25th of last April. A writer in NICHOLSON's *Journal of Science*, states that he has made a calculation of the average annual amount of damage done by lightning in England alone, and that it cannot be far short of fifty thousand pounds.

In the British Navy the effects of lightning have been most disastrous. Since the commencement of the war in 1793, more than two hundred and fifty ships are known to have suffered in thunder-storms. It is not possible to state with any degree of precision the total amount of damage done, as all the instances in which ships have suffered cannot be well ascertained: some idea, however, may be formed of it from the following facts derived from the official journals of Her Majesty's ships, deposited at the Admiralty. In one hundred and fifty cases, the majority of which occurred between the years 1799 and and 1815, nearly one hundred lower masts of line-of-battle ships and frigates, with a corresponding number of topmasts and smaller spars, together with various stores, were wholly or partially destroyed. One ship in eight was set on fire in some part of the rigging or sails; upwards of seventy seamen were killed, and one hundred and thirty-three wounded, exclusive of nineteen cases in which the number of wounded is returned as "many" or "several." In one-tenth of these cases the ships were completely disabled, and they were compelled in many instances to leave their stations, and that too at a critical period of our history. The expenditure in these few cases in the mere material, could not have been far short of one hundred thousand pounds sterling. So that if the whole amount of the loss to the public, in men, in money, and in services of ships, could be ascertained, it would necessarily prove to be enormous; more especially when we take into account the expense of the detention and refit of the damaged vessels, the average cost of a single line-of-battle ship to the country being one hundred pounds per diem and upwards. Now between the years 1809 and 1815, that is to say, within the short period of six years, full thirty sail of the line, and fifteen frigates, were more or less disabled.

A very considerable portion of this mass of destruction occurred, it is true, at a time when a great number of ships were required; but at a more recent period, in time of peace, when the Navy has been greatly reduced, we find a large amount of these casualties to be constantly occurring. On

the Mediterranean station alone, between the years 1838 and 1840, the *Rodney*, *Powerful*, *Ceylon*, *Tribune*, *Scorpion*, *Wasp*, *Tyne*, and *Blazer*, were struck by lightning, and many of them severely damaged: the *Rodney*, in addition to the destruction of her main-mast, was set on fire. In little more than twelve months, about the year 1830, three line-of-battle ships, a frigate, and a brig, were also more or less disabled. In other parts of the world we have lately had the *Rhadamanthus*, *Gorgon*, *Snake*, *Racehorse*, *Pique*, and many others, damaged by lightning; and in 1832 the *Southampton*, of fifty guns, narrowly escaped being blown up in the Downs.

It has been suggested that many ships reported as "missing" have been destroyed in thunder-storms, a surmise almost converted into a reality, by the ravages which lightning is known to be capable of producing. From a reference to the official log of the *Lacedæmonian*, and to the evidence of Admiral Jackson, who then commanded her, it appears, that His Majesty's ship *Peacock* disappeared during a violent storm of lightning on the coast of Georgia, in the year 1814. The *Loup Cervier*, another of His Majesty's ships, was last seen off Charlestown, on the evening of a severe thunder-storm, and has not since been heard of. When His Majesty's ship *Resistance*, of forty-four guns, was blown up by lightning in the Straits of Malacca, in the year 1798, two or three of the crew were picked up by a Malay proa, which happened to be in company; but for this circumstance, the fate of this ship would have remained in the same obscurity which now hangs over so many vessels reported as "missing," as all the rest of the crew perished.

The journals of the ships of the Honourable East India Company furnish appalling statements of the damage and loss of life, caused by the electrical explosions which have fallen on them, while freighted with the rich products of the East: even so lately as 1842, the *Coote*, of twenty guns, one of the navy of this great mercantile power, had her masts shivered in pieces by lightning at Madras.

Though we have not the same means of ascertaining the damage done to our mercantile marine, yet the loss to the shipping interest, in consequence of lightning, must be extremely great. Scarcely a year passes, without a calamitous account appearing in the public prints, of some fine merchant ship having been damaged or totally destroyed. In March last the *Toronto*, one of the splendid packets which sail be-

tween London and New York, was struck by lightning, which killed one of the crew, and damaged the vessel; and in August, 1842, the *Defiance*, a large transport, laden with Government stores, including rockets and gunpowder, had her main-mast completely rent through to the keel by an electrical discharge off Nankin; the ship was filled with a sulphurous smoke, and the greatest consternation prevailed among the troops and seamen, from the dread of an immediate explosion. In May, 1840, the ship *Madras* was set on fire, and a portion of her side was driven out by an electrical explosion, and in 1839 a similar accident befel a large barque called the *John and James*, off Algiers, so that she was with difficulty prevented from sinking. In 1838, the *Orwell*, a large trader, laden with cotton, was set on fire, and narrowly escaped total destruction. Within a few years the merchant ships *Tanjore, Poland, Logan, Ruthelia, Bolivar, Boston*, and *Lydia*, are known to have been entirely consumed.

However well, therefore, the fact of electrical conduction may be known,—however well scientific men may be agreed that, by the judicious employment of metallic bodies, we may ensure protection against lightning,—certain it is that the principle itself is far from being generally understood, or universally adopted. Indeed, to *existing* prejudices arising entirely out of a misapprehension of the laws of electrical discharge, may be traced the great destruction of life and property, so frequently occurring from the effects of lightning.

It is not easy to explain how, in the present advanced state of natural knowledge, so many anomalous views and opinions on this interesting subject should pervade the public mind, since in no department of physical science is the field of observation more fertile, or the path of experience more direct and certain. We have at our command the results of observation for nearly a century, during which time lightning-rods have been employed; a great many instances are to be found, in which lightning has fallen on buildings under a variety of peculiar circumstances. In some cases lightning-rods have been present, in others not; moreover, we can successfully imitate by artificial means the great operations of nature, and examine experimentally every probable result of a shock of lightning, and every possible contingency attendant on it. We ought, therefore, to find no difficulty in arriving at a practical solution of such questions as these:—Is the application of a lightning-conductor desirable in any particular case? May it, by a species of attractive force inherent in it,

cause a discharge of lightning, which otherwise, would not have occcurred in this particular direction? If so, may it occasion the damage it was set up to avert, through its inability to meet the explosion that may fall on it? Is it liable to produce destructive effects, by any species of lateral discharge of the electricity in passing along it? What are the best dimensions and form of a lightning-conductor? and such like. If such questions as these cannot now be determined, they in all probability never will be.

To bring the subject, therefore, of lightning-rods, and the amount of our knowledge of their practical operation, into such a form as may be readily apprehended by those whose habits of inquiry have not led them into scientific pursuits,—and to remove the misapprehension which exists as to the attractive effect of metallic bodies in storms of lightning, is the object of this treatise; and as it is most important, that no means of protection from danger which we are permitted to employ, should, through the prevalence of popular misapprehension, or want of information, be unwisely neglected, I cannot but venture to hope, that with so many important facts before us, the following pages may not be deemed altogether uncalled for, or without claims to public attention.

SNOW HARRIS.

6 *Windsor Villas, Plymouth,*
May 1, 1843.

INTRODUCTORY REMARKS

TO HARRIS'S WORK ON THE NATURE OF THUNDER-STORMS.

In the preceding sections we have considered the physical conditions of a thunder-storm, and the laws and mode of operation of electrical discharges. From these inquiries we have deduced certain practical results relative to the employment of metallic substances under the form of lightning-rods, as a means of protection against the calamitous effects of lightning.

We now propose to examine such evidence as we possess of the efficacy of lightning-rods, whether they have met all the conditions required for perfect security against discharges of atmospheric electricity, without endangering the buildings to which they are applied, and finally to inquire into the validity of certain popular objections to their general employment.

It may be perceived, that in all these researches we have adhered carefully to the safe and beaten path of inductive science: in no case has any advance unwarranted by facts been attempted. The same caution will be observed in examining the different views which have been entertained of the efficacy and action of lightning-rods. For, as it has been beautifully remarked by Lord Bacon, the great father of inductive science, "Man, who is the servant and interpreter of nature, can act and understand no further, than he has either in operation or in contemplation observed of the method and order of nature."

Whether Lightning-Rods and other Metallic Conductors have effectually guarded Buildings, &c. against Damage by Lightning.

In the year 1839 the Lords Commissioners of the Admiralty appointed a naval commission to investigate the best

method of applying lightning-conductors to Her Majesty's ships. After a very elaborate inquiry, they drew up a report on this important question, extending to more than eighty folio pages, and containing a valuable mass of oral and documentary evidence, received from naval officers, men of science, and other competent persons. This report was laid on the table of the House of Commons, and in February, 1840, was ordered to be printed. One of the points to which the commission directed its attention was this: "Whether in cases in which ships *not having* lightning-conductors have been struck by lightning, it appears that other ships in company *having* lightning-conductors, have either not been struck, or have escaped injury." The following are some of the cases which were brought under the notice of the Commissioners:—

In 1815, His Majesty's ship *Norge*, was severely damaged by lightning, whilst the *Warrior*, of seventy-four guns, with a pointed conductor, lying close to the *Norge*, received no injury. The electrical action in this case illuminated the linked portions of the conductor, and appeared to stream down into the sea. There were many other ships in the harbour, but none received any damage except one, *and this ship was the only one which had not a conductor.*

In February, 1824, His Majesty's ship *Milford*, not having a lightning-conductor, was struck by lightning in the Hamoaze, Devonport, and damaged, whilst His Majesty's ship *Caledonia*, of one hundred and twenty guns, about eighty fathoms distant, having pointed conductors, escaped.

In September, 1824, His Majesty's ships *Phaeton* and *Adventure* were lying at Gibraltar Mole: the *Phaeton* had not conductors, but the *Adventure* had: the ships were within a cable's length of each other. Under these circumstances, the *Phaeton* was struck and damaged by lightning; the *Adventure* escaped.

In January, 1830, His Majesty's ships *Madagascar*, *Ætna*, and *Mosquito*, were about to come to an anchor off Corfu. A violent thunder-storm arose, which struck and severely damaged the *Madagascar* and *Mosquito*, the ships without conductors; the *Ætna*, which had a conductor at the main, although struck by lightning repeatedly on this mast, escaped.

In 1837, the *Cochin*, tank-vessel, in Trincomalee harbor, had her foremast shivered by lightning, whilst Her Majesty's ship *Winchester*, about two cable's length distant, escaped. The *Winchester* had a conductor, and the lightning was

observed to stream down it; the tank vessel on the contrary, was undefended.

In November, 1837, the *Pelican*, of sixteen guns, without a conductor, was struck by lightning on the coast of Africa, and damaged; the *Waterwitch*, another of Her Majesty's ships, at anchor within a short distance, escaped.

In March, 1838, Her Majesty's ship *Ceylon*, in Malta harbor, was struck by lightning, which shivered the fore-mast; she had no conductor. Her Majesty's ships *Talavera* and *Bellerophon*, both furnished with lightning-conductors, escaped, as did the sheers for masting ships, which were similarly armed. This instance is the more remarkable, from the fact that the *Ceylon*, as a receiving ship, had only a short pole above her fore-mast, whereas the other ships, being fully rigged, their masts extended above one hundred and fifty feet into the air.

"In addition to these instances," say the Commissioners, "we beg to call their Lordship's attention to the case of the New York packet, laid before the Lord High Admiral in 1827, by the Navy Board. It appears that on her passage to Liverpool, in 1827, this ship was struck by lightning, and sustained considerable injury. The conductor was not up at the time; but the weather continuing stormy, it was got out, and triced up to the mast-head. The ship was a second time struck by a most severe stroke of electricity, which fused the chain, and passed into the water without doing further damage."

The following are some additional cases conclusive of the efficacy of lightning-rods as a defence against lightning, the ships having been fitted with pointed conductors fixed in all their masts:—

His Majesty's frigate *Dryad* was struck by lightning in a tornado on the coast of Africa in 1830. Commander Turner says, "that the discharge fell on both the fore and main-masts with a loud whizzing sound; the thunder was nearly simultaneous with the lightning, and the ship appeared enveloped in flames."

His Majesty's frigate *Druid*, at Rio Janeiro, in 1832, encountered awful lightning, which was conducted safely down the conductors on the fore and main-masts."*

His Majesty's ship *Asia*, in the Tagus, in 1831, was assailed by lightning during a squall with heavy rain; the electrical ex-

* *Report of Commission*, p. 94.

plosion passed off safely upon the conductor on the main-mast.*

Her Majesty's frigate *Talbot*, in July, 1842, was struck by lightning soon after getting under weigh at Sheerness. The lightning was observed to fall immediately on the conductor when the cloud burst over the main-mast head.†

The cases of the *Beagle* and *Actæon*, before referred to, furnish very complete and important evidence of the beneficial operation of pointed conductors.

Lieutenant Sullivan, who had witnessed the effects of lightning in shattering the mast of His Majesty's ship *Thetis*, happened to be on duty at the time the electrical discharge fell on the *Beagle;* he states that, "when the clouds by which the ship was enveloped burst on the mast, the mast and ship appeared to be wrapped in a blaze of fire; the vessel trembled under the crash of the thunder, and a vibratory whizzing sound was heard along the conductors."

Lieutenant Bonham, and Mr. May, the carpenter, who were both on deck when the *Actæon* was assailed by lightning, describe very similar effects. The discharges occurred within a fearfully short distance of the ship, and the flashes were so vivid, that the observers were for a time deprived of sight. When the ship was struck, the lightning was observed to fall immediately on the conductor; the crash of the thunder was intense and simultaneous with the lightning. The cutlasses stowed around the mast rattled in their stand, and there was a loud whizzing sound upon the conductor which appeared enveloped in electrical fire.‡

These cases which have much in common, are characterized by well known phenomena of electrical action; they have occurred in various parts of the world, at different times, and have been reported on by persons in no way interested in perverting the facts: hence no doubt can remain as to the decisive evidence they afford, of the protecting power of pointed conductors.

The Commissioners conclude their remarks on the first head of their inquiry in the following words: "Every search has been made for cases of injury sustained by ships fitted with conductors; and though several statements to that effect

* Witnessed by Mr. Sadler, the master of the ship.

† Reported to the Lords of the Admiralty.

‡ Account by the master.

have been brought under our notice, *not one has been substantiated.*"*

Finally, it is not unimportant to observe, that since the year 1829, above thirty of Her Majesty's ships have had pointed conductors fixed in all their masts. These vessels have been at sea, and exposed to severe thunder-storms in all parts of the world; and although, as we have just shown, heavy electrical discharges have fallen upon them, yet in no instance has any damage or inconvenience been experienced. On the other hand, about forty-one vessels, not fitted with fixed conductors, (more than one-fourth of the average number of ships at sea, or on foreign stations) are known to have been struck and damaged during this period.

Whether Lightning-Rods attract Lightning.

Amongst the objections made to the employment of lightning-rods, there appears to have been none so popular, and at the same time so plausible, as this, viz., that by setting up pointed conductors we invite lightning to our buildings, which otherwise would not fall on them; that should the quantity of electricity discharged be greater than the rod can carry off, the redundant quantity must necessarily act with destructive violence; and that since we can never know the quantity of electricity which may be accumulated in, and be discharged from, the clouds, it is not improbable but that any conductor which we can conveniently apply, may be too small for the safe conveyance of such a charge.

Although the advocates of these opinions have never adduced any substantial fact, or any known law of electricity, in support of them; although they have never, by any appeal to experience, shown that buildings armed with lightning-rods have been struck by lightning more frequently than buildings not so armed, nor demonstrated any single instance in which an efficient lightning-rod, properly applied, has failed to afford protection,—nevertheless such views have been commonly

* This observation is limited to the protective effect of the conductor on the mast to which it is attached, as in some few instances damage has ensued to one of the masts of a ship having a small conductor on another mast at a distance from it. Amongst the statements alluded to, were the cases of His Majesty's ships *Kent* and *Perseverance*, said to have been the only ships in a fleet damaged by lightning, and to have been the only ships having lightning-conductors. See *Mech. Magazine*, vol. viii. pp. 13 and 287.

entertained: indeed so strenuously have they been insisted on, and that too by persons of education and influence, that the Governor-general and Council of the Honorable the East India Company were led to order the lightning-rods to be removed from their powder magazines and other public buildings, having in the year 1838 come to the conclusion, from certain representations of their scientific officers, that lightning-rods were attended by more danger than advantage; in the teeth of which conclusion, a magazine at Dum Dum, and a corning-house at Mazagon, not having lightning-rods, were struck by lightning and blown up.*

In a work on Canada, published so lately as the year 1829,† we find the following passage: "Science has every cause to dread the thunder-rods of Franklin: they attract destruction, and houses are safer without than with them. Were they able to carry off the fluid they have the means of attracting, then there could be no danger, but this they are by no means able to do." Assertions such as these, appealing as they do to the fears of mankind, rather than to their dispassionate and sober judgment, have not altogether failed in obtaining that sort of temporary favor which so frequently attends a popular prejudice, promulgated without reason, and received without proof. Not only is the idea that a lightning-rod invites lightning unsupported by any fact, but it is absolutely at variance with the whole course of experience.

The notion that a lightning-rod is a positive evil, appears to have arisen entirely out of assumptions, and a partial consideration of facts. Thus in consequence of the track of a discharge of lightning being always determined through a certain line or lines, which upon the whole least resist its progress, it has often been found to fall in the direction of pointed metallic bodies, such as vanes, vane-spindles, iron bars, knives, &c. The instances in which these bodies seem to have determined the course of lightning have been carefully recorded, the phenomena being peculiarly striking and remarkable; but on the other hand, no attention has been given to those instances in which lightning has altogether avoided such bodies, and passed in other directions. Now it will be found, as we shall presently show, that the action of a pointed conductor is purely passive. It is rather the patient than the agent;

* Correspondence with the Honorable Board of Directors; Professor Daniell and Dr. O'Shaughnessy.

† *Three Years in Canada.* By F. McTaggart, Civil Engineer in the service of the British Government.

and such conductors can no more be said to attract or invite a discharge of lightning, than a water-course can be said to attract the water which flows through it at the time of heavy rain.

We have shown, in a former section, what quantity of metal is really sufficient for the perfect conduction of any quantity of lightning liable to be discharged in the most severe thunder-storms: therefore, to assume that any conductor which may be applied is not sufficiently capacious, is to reason against experience, and to resort to a species of argument quite foreign to the conditions of the case. It would be, as if we were to insist upon the danger of applying water pipes to buildings, under the assumption that we do not really know what quantity of rain may possibly fall from the clouds, and that hence the pipe may after all be too small to convey it.

In all these reasonings we should recollect, as already explained, that the forces in operation are distributed over a great extent of surface, and that the point or points upon which lightning strikes is dependent on some peculiar condition of the intervening air, and the amount of force in operation,—not on the mere presence of a metallic body projecting for a comparatively short distance into the atmosphere,—"that such bodies provoke the shaft of heaven is the suggestion of superstition, rather than of science."*

We shall now leave the theoretical discussion of this question, and direct attention to the facts themselves, and examine how far the evidence deducible from such facts is conclusive upon this important point.

During the thunder-storm which spread over the neighborhood of Plymouth, in May, 1841, the electrical discharge struck one of the high chimneys at the Victualling-Yard; it fell also on the top-mast of the sheer-hulk off the Dock-yard, about a mile and a half distant. Now the circumstances attendant on these discharges of lightning bear directly on the question before us. The chimney at the Victualling-Yard is a round column of granite, about one hundred and twenty feet high, attached to the bake-house; it *has not a particle of metal in its construction, nor has it any projecting point.* It stands at a distance of about one hundred yards from a clock-tower in the same yard; which, on the contrary, *has* not only a metal vane, and cross-pieces of metal, indi-

* Leslie, *Edin. Phil. Mag.*

cating the four cardinal points, but its dome is covered with copper, and there is a large conductor continued partly within and partly without the tower, from the dome to the ground. In the sheer-hulk a very small metallic wire was led along the pole top-mast, and connected with the large metallic chains attached to the mast and sheers: the height of this pole was comparatively low, and it was completely overtopped by the neighboring spars of the line-of-battle ship *Cornwallis*, fully rigged, and fitted with conductors on each of her masts. Now when the disruptive discharges took place, they fell on the granite tower, which had not a single metallic substance in its construction, and on the low flag-staff pole of the sheer-hulk's mast, notwithstanding that the clock-tower near the chimney offered every possible "invitation" to the discharge, and the great altitude of the line-of-battle ship's spars were in the most favorable position for "attracting" the electrical explosion. The chimney was rent for sixty feet; the flag-staff of the hulk's mast was slightly injured, and the small wire broken and fused; the lower masts and chains were uninjured.

On the 25th of March, 1840, Her Majesty's ships *Powerful* and *Asia*, each of eighty-four guns, were at anchor within a short distance of each other in Vourla Bay, in the Mediterranean. The *Asia* had the fixed pointed conductors attached to each of her masts; the *Powerful* was unprovided with any lightning-conductor whatever. Under these conditions they were both exposed to a severe thunder-storm. A discharge of lightning fell on the *Powerful*, the ship without conductors, and shivered some of her spars; whilst the *Asia*, where every supposed "invitation" to the discharge was most prominent, experienced no ill effect.

If no other cases were on record, these alone, would be sufficient to dispel all apprehensions of a metallic conductor "attracting or inviting" lightning. A great number of instances, however, equally clear and satisfactory, exist; from these we have selected the following:—

Amongst some interesting remarks on the effects of lightning, by Professor Winthrop, communicated by Dr. Franklin to Mr. Henley, it is stated, that a tree which stood at the distance of fifty-two feet only from a pointed conductor attached to a house, was struck by lightning and shivered, while the conductor and house escaped,*—that is to say, the lightning

* *Phil. Trans.* vol. LXIV., p. 152.

fell on a body, which, according to the prevalent notion, had little or no attraction for it, and held out no "invitation," in preference to one which did,—a fact totally at variance with the whole assumption.

We have already adverted to the case of the *Southampton*, in which a heavy electrical discharge fell upon the sea close to the ship, during a thunder-storm on the east coast of Africa. But what makes this case especially applicable to the question now under consideration, is the circumstance that all her masts were fitted with fixed lightning-conductors, which terminated in copper spikes. The storm was awful, and is stated by Mr. Martin, the master, to have lasted from ten P. M. to two A. M. "The night was pitchy dark, from the density of the surrounding clouds: the roar of the thunder was incessant, and the flashes of lightning frequently so vivid, as to affect the sight for some minutes," yet no ill effect was experienced; the electrical discharge was not drawn down in an explosive form exclusively upon the conductors, although it actually fell with violence upon the sea close to the vessel.

Similar effects were observed in His Majesty's ship *Sapphire*, armed with pointed conductors of the same kind. Captain Wellesley, who commanded this ship, states that "the lightning was so vivid, and the flashes so quick in succession all around the ship, that although the duty to be done was important, I hesitated to expose the crew to them;* yet the ship was not struck." In another place he states, "that the *Sapphire* often met with very severe lightning, but it was never attracted to her."†

The frequent instances in which lightning avoids the most prominent parts of buildings, and falls obliquely upon some point far removed from them, may be further adduced as evidence against the attractive influence of such projections. The long zig-zag track of lightning, arising from the resistance of the air to its more direct path, may cause it to fall very obliquely on the earth's surface, as is well known: indeed, some of the directions of the zig-zag, may become almost horizontal. Now, in these cases, the pointed extremities of a tower, or the masts of ships, have no influence whatever on the course of the explosion; which finds its way through the least resisting interval. Mr. Alexander Small

* They were afraid to hoist the boats out.

† *Report of Commission on Shipwreck by Lightning.*

states, in a letter to Dr. Franklin, that he saw an explosion of lightning pass before his window in a direction nearly horizontal, and strike a clock-tower far beneath its summit.

In the discharge of lightning, which fell on His Majesty's ship *Opossum*, in the English Channel, in March, 1825, "a peal of thunder burst on the main rigging, and split the top-mast cap."* Her Majesty's ship *Pique* was struck by lightning in the St. Lawrence, in November, 1839, by a discharge which fell on the fore-mast just beneath the head of it, and from thence passing down the mast, did considerable damage. Such cases, although comparatively rare, and to a certain extent exceptions to the general course of lightning, are still sufficient to show how little the direction of electrical explosions is determined by the influence of points *considered as mere attractors*, and that it is only when they can contribute to the equalization of the opposite electrical forces, that lightning strikes on them. Franklin, in endeavoring to draw off the electricity of a charged sphere by means of a pointed wire, found that the point when placed on a rod of glass or wax, had no action on it.†

When this large mass of evidence is duly considered, together with the fact, that lightning strikes indiscriminately, trees, rocks, and buildings, and even the ground near them, we are compelled to admit that the thunder-rods of Franklin are perfectly precise in their operation, and that the common notion that they "invite destruction" to our buildings, is not warranted by any sound argument drawn from experience.

It may not be unimportant to notice here the following extract from the *Memoirs of the Count de Forbin.* In describing the large St. Helmo's fires, observed in the vane of the main-mast, he says, "I ordered one of the sailors to take it (the vane) down; but scarcely had he taken the vane from its place, when the fire fixed itself on the head of the main-mast, from which it was impossible to remove it;"‡ so that the presence of the metallic point was not at all necessary to the electrical discharge.

Before quitting the subject of the absolute protection from lightning afforded by conductors, the Naval Commission inquire, whether, according to the common prejudice, conductors have the power of *attracting* a flash of lightning, which

* Ship's log.

† Franklin's *Letters*, p. 56.

‡ *Letters on Electricity.* By the Abbe Nollet.—Vide *Phil. Trans. for* 1753, p. 201.

in their absence would not have occurred; and their report states "that the instances of accidents to ships *without conductors*, and the comparatively rare occurrence of lightning being observed to *strike* on a conductor, would tend to negative such a supposition."* They further consider, from the instances which were submitted to them, of ships without conductors having been struck by lightning, in the presence of ships furnished with them, which were not so struck, that most complete evidence is afforded "either of the little influence exerted by such conductors in inducing or attracting an explosive discharge, or of their efficacy in harmlessly and imperceptibly conveying away electricity to the water."†

The limits of this pamphlet will not permit me to extract much valuable matter on the subject of conductors to buildings, and the effects of strokes of lightning on those having no conductors, or those of defective construction; all of which Mr. Harris treats at great length, citing many instances and many learned authorities on the subject of lateral discharges. He says:—

It may be here observed, that if lightning-rods are liable to produce lateral explosions upon surrounding bodies, so as to set fire to inflammable matter, and cause other destructive effects; then there is not a powder magazine in Europe, armed with such rods, which, upon being struck by lightning, would not either be blown up or damaged; but this at least we have shown has never been the case.

The electrical explosion which passed down the chain conductor of Her Majesty's ship *Dublin*, and by which it was disjointed and partially melted, did not in any degree injure, by a lateral explosion, the small rope to which the chain was attached, nor were there any lateral discharges thrown out upon the various metallic substances near which the conductor passed.

In the numerous instances in which lightning has been discharged into the sea by the bolts in the solid timbers and planking of ships, we do not find any trace of a lateral discharge; although in large ships these bolts are several feet in length. Soon after the terrible shock of lightning had fallen upon the *Chichester*, Captain Stewart thought it necessary to

* *Report of Commission*, p. 4. † *Report of Commission*, p. 4.

haul the vessel up. "I examined," says he, "the planks about the bolts, and found all quite firm and water-tight." In all the cases in which dense explosions have been transmitted by conductors fixed to the masts of ships, no lateral discharge has occurred; yet they are very near a succession of metallic bodies,—viz., sheaves and pins, funnel for rigging, iron-bound caps, eye-bolts, chain-slings, mast-hoops, and even the great masses of the chain cables and water tanks.

Mr. Harris says, under the head of instances in which buildings provided with pointed conductors are said to have been damaged by lightning, that "although several instances have occurred in which buildings having pointed lightning-rods have been damaged, yet is it a singular fact, that they may all be quoted in illustration of the great advantage of such rods, in safely transmitting heavy electrical discharges from the atmosphere."

We have shown, by reference to a variety of cases, both the small influence of pointed conductors in attracting or causing explosions of lightning, and the liability of the discharge to break up, before reaching the earth, into two or more streams. In the cases of damage by lightning said to have occurred, notwithstanding the presence of a pointed conductor, the electrical discharge has divided in the air, into two or more streams, previously to striking the building. One portion has commonly struck upon the conductor, and been carried off by it, whilst other portions have fallen on points far distant from the conductor.

In so long a period as three quarters of a century, it is not to be expected that no casualties should occur, either from a defective application of the conductor, or from an explosion falling on some part of the building at a distance from the conductor. But the few accidents on record can scarcely be urged as an objection to the general principle, especially when we take into consideration the great number of lightning-rods set up in various parts of the world. In the United States alone, some thousands of lightning-rods have been erected since the time of Franklin's great discovery; yet only two instances are quoted, in which damage occurred there, and these, as we have endeavored to show, do not warrant any distrust of the principle on which such rods are applied.

Mr. Harris sums up this mass of valuable information, contained in a book of 226 pages, with the following

CONCLUDING OBSERVATIONS.

Upon a review of what has been advanced in the course of these pages, relative to the nature of thunder-storms and the operation of lightning-rods, it appears, that buildings and other elevations are struck and damaged by lightning, only in consequence of there being points in one of the terminating planes of a great electrical disturbance in the atmosphere; not from any property of attraction for the matter of lightning, inherent in the substances of which such elevations are composed:—that lightning-rods remove, by the aptness of their parts, the resistance experienced by the electrical discharge in moving through less perfect conducting matter; and hence, by allowing a rapid and free neutralization of the opposite electrical powers, they prevent the damage attendant on an obstructed action:—that the operation of such rods, being of a purely passive kind, they can no more be said to invite or draw down lightning upon the buildings to which they are applied, than a rain-pipe can be said to draw down or invite the rain which flows through it:—that such a passive property cannot be fairly adduced as an argument against their general use:—that since lightning-rods only operate in transmitting as much electricity as falls on them, they cannot be prejudicial to buildings, but must, on the contrary, by a rapid annihilation either of the whole or part of the force in action, necessarily contribute to security:—that lightning, being nothing more than the electrical discharge moving through bad conducting matter, under an explosive form, the tendency of a lightning-rod is to deprive the discharge of this form from the instant it falls on the point of the rod, and by converting it into an evanescent current, through matter calculated to assist its progress, to annihilate it as lightning altogether.

In the treatment of this question, it was not possible to avoid a frequent appeal to electrical action, on the great scale of nature. If, therefore, the remarkable instances quoted, of lightning striking on buildings and ships, should appear to be somewhat numerous, and to be treated of in too great detail,

yet it must be recollected, that it is only by pursuing such a course that we can hope to arrive at deductions worthy of confidence. Hence it is, that in the progress of these inquiries we have been led to adhere carefully to a series of well-authenticated facts, and by keeping strictly within the safe path of inductive science, we have endeavored to throw some further light on a subject of very great public importance, which has not been generally or fully appreciated. With respect to certain prejudiced views and opinions which have been entertained of the operation of lightning-rods, we trust to have made it appear, that such opinions are founded on no sound basis whatever; and that a judicious application of pointed conductors, both on land and at sea, is not only desirable, but is, in a great variety of cases, quite essential to the preservation of buildings and ships from the ravages of lightning.

I have thus endeavored to condense the facts contained in W. S. Harris's works, selecting the parts relating to ships rather than buildings, because ships are most neglected. If I shall succeed in awakening public attention to this important subject, and thereby be the means of saving life and property, I shall feel amply repaid for the little labor I have performed.

NOTE.

R. B. Forbes, 48 State St., Boston, invites navigators to furnish him (post paid or not) any authentic information on strokes of Lightning—giving date—damage to ship or crew,—to enable him to make up some statistical facts.